CLOUD-BASED BUSINESS INTELLIGENCE AND ANALYTICS APPLICATIONS – BUSINESS VALUE AND FEASIBILITY

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Abstract

In several application domains, Cloud Computing has been established as an accepted IT sourcing alternative. The usage in more sophisticated areas like Business Intelligence and Analytics (BIA) is, however, still in its infancy. The presented research aims at carving out viable application scenarios for Cloud BIA and at analyzing them regarding their potential business value and feasibility. The scenarios are derived from a case study and are further explored quantitatively with a survey of BIA experts. The results indicate that while there is an interest in Cloud-based BIA solutions, it is mostly directed towards self-contained and simple front-end driven solutions. Furthermore, the study highlights the need for a broader perspective on the subject of Cloud BIA that also considers issues of organizational and technical compatibility. The findings contribute to BIA research by gathering insights into the adaption of Cloud BIA. For business practice, the results support a more differentiated approach towards integrating Cloud technologies into the BIA landscape.

Keywords: Business Intelligence, Cloud Computing, Outsourcing

1 INTRODUCTION

The field of Business Intelligence and Analytics (BIA) has to cope with several significant challenges: information needs are becoming more volatile in today’s highly interconnected and dynamic business environments, complexity and heterogeneity increase due to the inclusion of new user groups, and the trend towards Big Data applications changes BIA infrastructures and injects new components for data storage and analysis (Chen et al. 2012; LaValle 2009; Wixom et al. 2014).

A partial remedy for the associated problems might be the move to the Cloud (Gurjar & Rathore 2013). In particular, Cloud Computing promises to reduce costs and increase the agility of BIA at the same time. In fact, Cloud-BIA has been claimed to be a major lever for an increased BIA agility (Demirkan & Delen 2013; Mircea et al. 2011; Thompson & van der Walt 2010). But whilst a lot of areas are already successfully using Cloud technology, the adaption to the complex field of BIA is still in the early stages with actual adoption rates only at around 10% according to industry studies (Bitterer 2014). Reasons stated by users include a fear of insufficient security as well as challenges in the technical integration (Armbrust et al. 2010; Marston et al. 2011).

This raises the question under what circumstances the application of Cloud BIA is technically possible and economically viable. This research takes a differentiated stance by aiming at defining concrete application scenarios and at analyzing them with respect to their business value and their implementation feasibility. The results are intended to help identifying possibilities and limitations of Cloud BIA and to support adaption decisions in real world scenarios. It is therefore supposed to contribute to the body of research on Cloud-based sourcing, BIA sourcing, and BIA agility.

The course of this paper is as follows: The next section introduces relevant terms and concepts. Afterwards, we illustrate the chosen methodology and research design. The fourth section depicts the results of the case study and the results of the conducted survey. After that, we discuss the results and identify core findings. Finally, we give a summary and a brief outlook on forthcoming developments.

2 CLOUD-BASED BUSINESS INTELLIGENCE AND ANALYTICS

Business Intelligence evolved from individual Management Support Systems (Morton 1983) to more integrated IT-based approaches to enterprise-wide decision support. It is still continuously pushing forward into new application areas (Chen et al. 2012; Wixom et al. 2014). To cope with the manifold requirements that such an integrated approach involves, a BIA infrastructure usually contains several sub-systems and is spread over multiple layers (Figure 1).

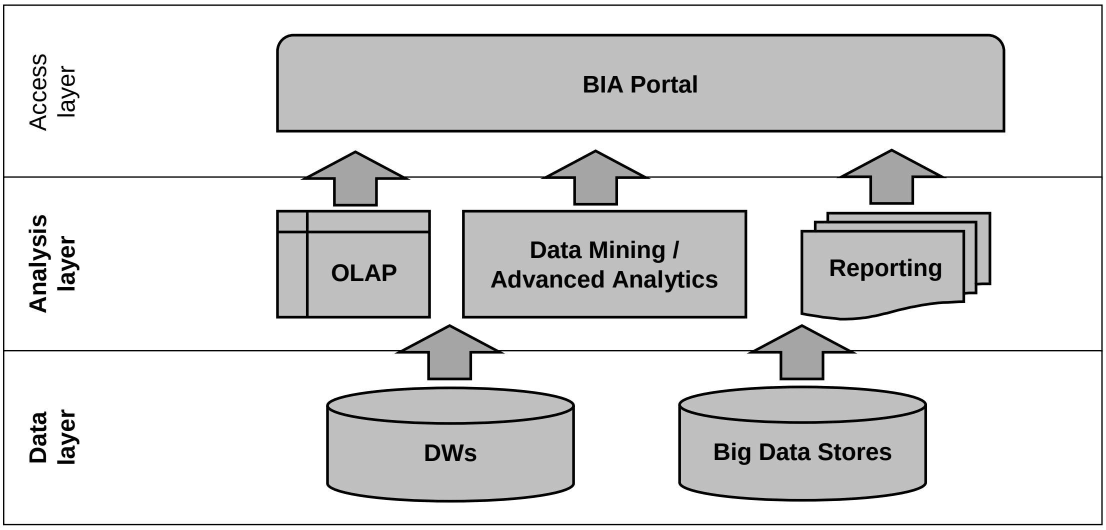

Figure 1. Three layer BIA architecture

Common is a distinction into

1) some kind of *data layer* that is responsible for storing and integrating data in an integrated and consistent form adequate for decision support. The data layer contains components like the data warehouse (DW) which represents a "subject-oriented, integrated, time-variant, and non-volatile collection of data" (Inmon 2005) and data marts that usually base on the DW. With the rise of Big Data solutions, these components are also supplemented with techniques to handle large and volatile datasets (Chaudhuri et al. 2011), e.g. based on frameworks like Hadoop. In the following, such repositories will be referred to as Big Data Stores (with the data lake as an application-independent raw data collection being a special variant of a Big Data Store).

2) An *analysis layer* that contains components that allow to refine and analyze the data from the data layer. The analysis layer includes tools for reporting and OLAP, as well as model-based systems esp. from the realms of Data Mining / Advanced and Predictive Analytics (Moss & Atre 2003). Again, new technologies on this layer come from Big Data applications with components for handling streaming data, visual and spatial analytics, network analysis, making poly-structured data accessible etc. (Kambatla et al. 2014; Chen et al. 2012).

3) An *access layer* is needed to integrate all relevant components and to present them to the user e.g. with the help of portal solutions.

The inclusion of Big Data technologies is currently shaking up BIA infrastructures. This adds to the already pressing demands to react rapidly and efficiently to both foreseen and unforeseen requirements, i.e. to enhance *BIA agility* (Cohen et. al. 2009; Zimmer et al. 2012). BIA agility is needed to deal with business and legal environments, more demanding users, and for the provision of BIA solutions that cross enterprise borders. By supporting the ad-hoc provision of solutions, solution prototypes, or solution components, Cloud Computing might become a relevant building block for BIA agility (Baars & Hütter 2015).

The term "Cloud Computing" has been defined as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources […] that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell & Grance 2011). The on-demand character of Cloud Computing can be considered as a paradigm shift in IT sourcing, despite the fact that it is actually bundling a set of existing technologies like *Grid Computing* or *Application Service Providing*. The innovation in Cloud Computing is that it combines and enhances those approaches and adds an increased ease of use, a higher degree of virtualization, and a set of new service and business models (Böhm et al. 2011; Foster et al. 2008; Vaquero et al. 2008).

The expected benefits of Cloud Computing encompass cost cuttings, the reduction of IT complexity, as well as the increase of agility that directly follows from the scalable on-demand provision (Marston et al. 2011; Reeves et al. 2009). Cloud Computing can increase BIA agility through dynamic scaling and changing of BIA systems or a rapid provision of systems and data sources (Mircea et al. 2011). It quite literally supports the reconfiguration of a firm's resources for sensing and interpreting business signals, i.e. it has an impact on the company's dynamic capabilities (Teece et al. 1997), particularly sensing capabilities in the sense of Overby et. al. (2006**)**. Figure 2 illustrates the impact of Cloud Computing on BIA agility and the resulting value contribution for a company.

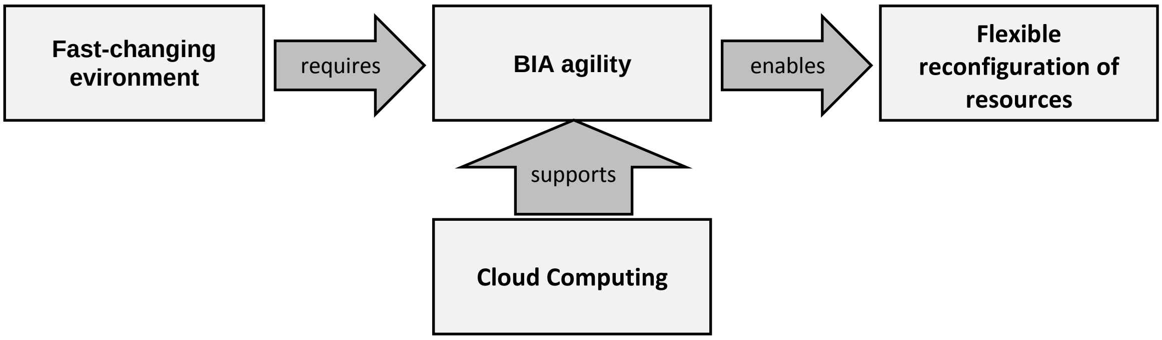

Figure 2. Cloud Computing as a lever for BIA agility and a facilitator of Dynamic Capabilities

Not only is the current application of Cloud Computing in BIA in the early stages, but academic research as well with only a limited number of publications on this topic (Kazeli 2014; Wang et al. 2011). Baars & Kemper (2010) derived a classification of potential Cloud-based BIA approaches with different degrees of granularity and types of commitment (Table 1).

Approaches	**Commitment**	**Granularity**
Add-on services	Short term	Service
Solution provision	Long term	Solution
Tool replacement	Long term	Component
Business network	Long term	Solution
Best of breed	Long term	Component
BIA mashup	Short term	Service & component

Table 1. Classification of Cloud-based BIA approaches

In a Cloud-based *add-on service* approach, isolated functional blocks are provided, e.g. for specific visualization or data processing tasks. This is already widespread in practice and thereby the most conservative approach (e.g. Geographic Visualization with Google Maps or text mining with IBM's Watson natural language-assisted data analysis service).

The *tool replacement* scenario describes a typical Software-as-a-Service approach where a company obtains an entire software tool, e.g. a Data Mart or an OLAP tool, over the Cloud. This concept usually comes with a larger scale than the add-on-services and also a rather long term commitment. Correspondent industry examples are cloud-based front-end tools like Tableau Public or TIBCO Spotfire Cloud. The *solution provision* is similar to the tool replacement but involves a larger scope as the provider becomes responsible for a complete solution – end-to-end and across all layers. Such an approach might be useful for specific temporary and standalone solutions like development sandboxes or data analytics environments. Though more and more big vendors release dedicated end-to-end Cloud BI stacks (e.g. Microsoft Power BI).

The *business network* scenario corresponds to the Community Cloud concept (Mell & Grance 2011) where parties with the same goals band together and share resources over the Cloud. This can particularly go along with data sharing approaches.

The last two scenarios are more forward-looking and might become realistic in the mid or long term future. In the *best of breed* approach, a company obtains all components from various external providers and therefore holds a completely virtualized BIA infrastructure. It therefore can be understood as an extended version of the tool replacement idea. Finally, the *BIA mashup* idea describes the vision of a freely composed BIA solution that can easily be set up with plug-and-play components sourced from a global Internet market space. The approaches will be used later for discussing applications derived from the studies.

3 METHODS

As Cloud-based BIA is a fairly novel field both in research and practice, this work has an explorative character with a focus on hypothesis generation rather than hypothesis testing. It is based on the conceptual framework depicted in Figure 3 that has the functions of organizing the elements of the research, structuring the research instruments and ensuring a systematic research process (Ravitch & Riggan 2011; Shields & Rangarajan 2013). Subject of the study is the concept of Cloud Computing and its application to solutions, components, or services of a BIA infrastructure (object of investigation). Instantiating the approaches from section 2, concrete Cloud BIA applications are defined that are analyzed with respect to their value contribution and feasibility. Coming from an IS view, this encompasses both aspects of technology and organization (Galliers & Land 1987).

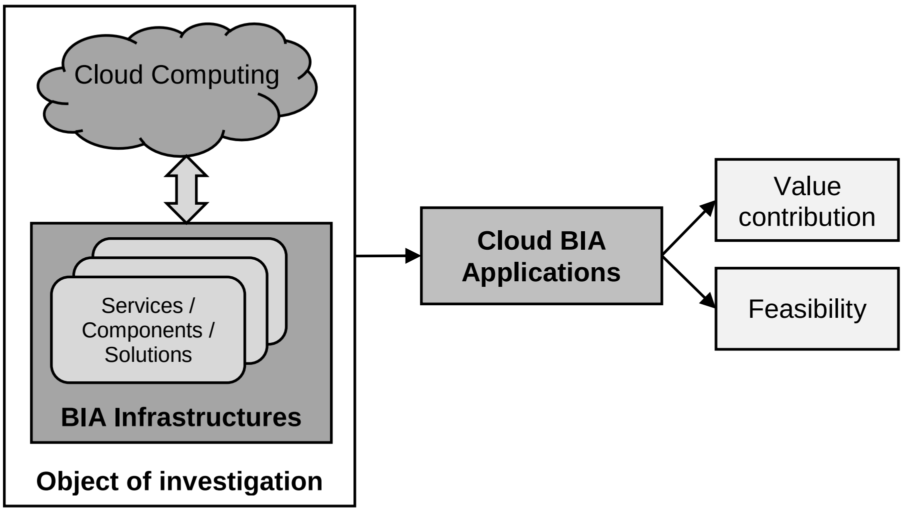

Figure 3. Conceptual framework.

The methodical approach of this work encompasses two sub-studies: 1) An exploratory *case study* that was conducted in cooperation with a large German life science company as well as 2) an online survey of various BIA experts (explorative quantitative study). The case study was chosen because of the explorative character of the research (Benbasat et al. 1987) and was designed according to the standards for Case Study Research (Yin 2013). Following the triangulation approach, the intention of the survey was to complement and generalize the results by combining the qualitative and quantitative methods (Denzin 1978; Kaplan & Duchon 1988; Mayring 2001) (Figure 4).

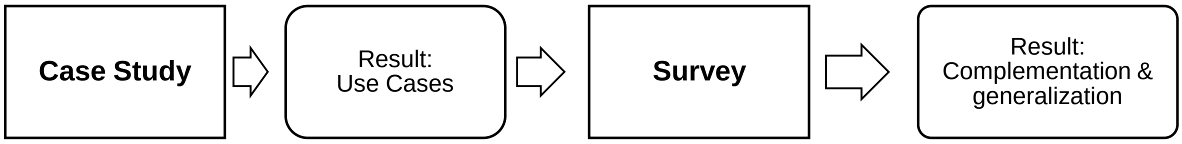

Figure 4. *Outline of the research design*

The goal of the case study was to analyze the (large and complex) BIA environment of the industry partner and to infer concrete application scenarios for Cloud BIA. We already did studies with the company before and gained insight into the BIA infrastructure and organization. The main case study was funded by the industry partner. During our research, we screened documents on the BIA landscape, the BIA strategy and on the Cloud governance; conducted five interviews with BIA experts of the company (from a central BIA/IT unit and an user department from a health care subsidiary); discussed the current BIA infrastructure as well as benefits and challenges of a Cloud adaption in three workshops. Simultaneously, we collaborated with the BIA unit in order to explore new Cloud approaches regarding the provision of a Supply Chain Management solution.

After the data collection, we abstracted and summarized the key statements of the interviews according to a summative content analysis approach (Hsieh & Shannon 2005; Patton 2005). Building up on the results and the approaches from section 2, we developed five applications of Cloud BIA. At this point, we intentionally restrained ourselves to realistic applications that we evaluated as becoming of relevance in the near or mid-term future.

The succeeding survey aimed to complement and generalize the findings from the individual case on a larger quantitative basis (Boudreau et al. 2001; Payne & Williams 2005). We drafted an online questionnaire that was preliminary tested with three interview partners of the case study, and was later sent to a sample of BIA experts gathered from a professional social network. In total, 600 German speaking BIA experts were contacted, of whom 75 replied (including 32 partial responses). All respondents represented BIA user companies. The majority of the participants came from the service sector (insurance and financial services, professional services) (70%), but there were also representatives of pharmaceutical (7%) and automotive (3%) companies and other industries (16%). The questionnaire included general questions about the situation of BIA and Cloud Computing in the company of the participants, on the perceived value and feasibility of the applications from the case study, as well as on some more specific issues of Cloud BIA.

We analyzed the result datasets with descriptive methods (like mean values, distribution analysis, correlation, and simple significance tests). All methods were chosen with respect to the return rate of the questions. Non-significant findings were neglected (Babbie 2015).

4 RESULTS

4.1 Findings of the Case Study

The experts did not see cost savings as the main driver for Cloud BIA. The main benefit was seen in the increase of agility that comes with the on-demand character. This can for instance speed up the setup process during the development of a solution or solution prototype – an activity that at the moment can take up to several weeks or even months.

When further investigating the BIA landscape of the company, it turned out that there were in fact Cloud components for smaller add-on BIA services (for visualization) and for proof of concept prototypes. But it also became clear that despite those small-scale systems, a high degree of interest, several pre-studies, and Cloud applications in other domains, the current BIA infrastructure did not yet contain any larger productive Cloud solution. The experts gave three main reasons for this. *Firstly*, the complexity of the BIA infrastructure was considered too high: The examined solutions included a multitude of dependencies, components from up to five vendors, and highly customized systems. *Secondly*, concerns about security and privacy when moving business critical data in the Cloud were deemed critical. And *thirdly*, proof of concept studies with selected systems in the company had shown that a BIA Cloud implementation comes at about the same cost as the current on premise operation, thereby removing the possibility of an easy cost-based rationale. Nevertheless, the company was planning a front-end application based on a Cloud platform that enables the firm's salesforce to access customer data at any time with their mobile devices. Besides this, it investigated a temporary Cloud-based provision of analytic tools for social media monitoring and analysis. It was furthermore explored to source master data management features from the Cloud and to move a Supply Chain planning and budgeting solution with multiple suppliers and customers to the Cloud (the current version of which is still hampered by performance bottlenecks and cumbersome and piecemeal solutions to issues of data sharing).

Next to the mentioned concerns about security and compliance with legal and internal regulations, the experts saw the complexity of the integration as a major challenge, particularly given the "best of breed nature" of the larger BIA solutions. A Cloud solution or component has to meet all functional requirements and has to integrate seamlessly in the existing infrastructure. Besides the technical perspective, Cloud approaches also have to be integrated in organizational structures and processes like the company's change management or support structures (as part of established IT Service Management (ITSM) implementations). One interviewee summarized these issues with the statement: *"You cannot move a system to the Cloud and then just say here we go"*.

On the basis of these results and the abstract scenarios from section 2 we developed the following five applications of Cloud-based BIA.

- **Integration of a Cloud-based front-end (instance of the tool replacement approach):**

  This case refers to an application that is restricted to the provision of a tool on the access layer, e.g. for channeling business data to the mobile devices of sales reps. For this application, a Cloud solution has the advantages of scalability and of taking the burden from the BIA units to cater the solution for the variety of devices. As the name implies, this application is a tool replacement scenario where the front-end tool from the Cloud is solely one component of a larger BIA solution.

- **Cloud-based analytics platform (instance of the solution provision approach):**

  This application is a platform to analyze large data sets, e.g. from a social network. The application brings specialized functionality for data storing and processing as well as software tools for accessing and visualizing data. With Cloud technology, a company can set up such a platform with high computing power on demand and later release it quickly if it is not needed anymore. This can save time and money since there is no need for acquiring new software or hardware. It is particularly useful if a platform is only needed for a time-limited project, e.g. in the realm of Data Mining / Advanced Analytics. Particularly if the analytics platform can be treated as an isolated BIA system (e.g. because the majority of the data comes from external sources as in the social monitoring case), this application represents a form of a solution provision approach.

- **Master data management services in the Cloud (instance of the add-on service scenario):**

  The idea behind this case is to provide a solution that loads data in the Cloud to eliminate duplicates or perform other data transformation tasks. Afterwards, the cleansed data is transferred back to a local system. Due to the flexible scaling, a Cloud solution facilitates complex seasonal transformation tasks and potentially decreases processing time. Since this function can be easily provided as a web service, the scenario corresponds to the idea of the add-on services in section 2.

- **Shared data in a Community Cloud (instance of the solution provision or best of breed approach):**

  This application illustrates the idea of a business network approach where several companies with similar interests share data over a Cloud-based data pool. This promises to improve cross-company cooperation processes, e.g. in a supply chain, or even enable new business models by gaining new insights from the enriched data. Depending on its architecture, such an application can instantiate a solution provision or even a best of breed approach.

- **Cloud-based end-to-end BIA stack (instance of solution provision, best of breed, or mashup approach):**

  The idea of an entire Cloud-based BIA stack – that covers a DW as well as data marts and front-ends – represents the use case with the largest scope. The advantage of a completely Cloud-based solution is that there is no need for any hardware or software and that maintenance is outsourced in its entirety. Furthermore, a company can benefit from the rapid provision and the on-demand scaling of such a solution. On the other hand, it is debatable if a Cloud-based BIA stack can satisfy the often highly individual requirements of the BIA users. If the stack is seen as a holistic solution provided by one vendor, this case can be seen as a solution provision scenario. But in a wider extent, the stack might represent a combination of different tools and solutions and therefore rather depicts a best of breed or even a BIA mashup scenario.

Even though the restrictive compliance rules in the company (with particularly strict requirements regarding security due to its research- and development-based business model and the nature of the industry that is both highly competitive and driven by costly innovations) were currently perceived prohibitive for most of the discussed applications by the users, the BIA experts stated their conviction that this will change in the future. For the time being, the interviewees saw the adaption of Cloud technology rather in specific and limited applications (e.g. a front-end or an isolated analysis platform) as more likely than in extensive scenarios like the virtualization of a complete BIA infrastructure.

4.2 Results of the survey

The survey showed that while the majority of the participants was not yet using Cloud BIA, almost a third (of those who replied) already claimed to have productive Cloud BIA solutions and another third was evaluating an adaption (Figure 5). Interestingly, all smaller companies (< 100 employees) except one were already using or have plans to use Cloud BIA, whilst 50% of attendees from larger companies (> 100 employees) denied to have plans to use Cloud-based BIA solutions. This observation however was statistically not significant (p = .05).

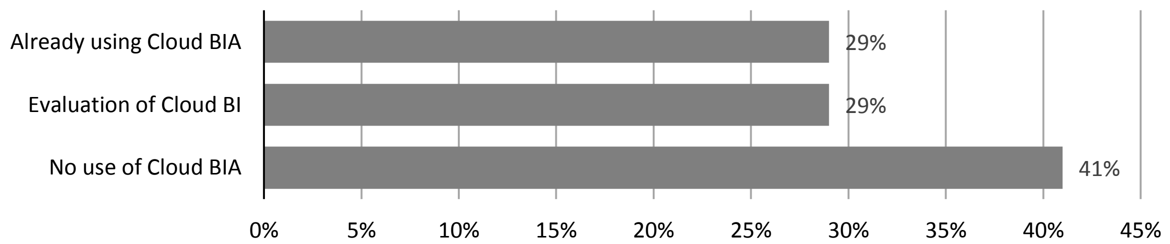

Figure 5. Situation of Cloud BIA in the companies of the survey [N=34]

The main part of the survey contained an evaluation of the five applications from the case study. We asked the participants to assess the value and the feasibility for their companies. This revealed that around half of the participants considered the Cloud-based front-end and the analytics platform applications to be of high value. The other three applications, however, were assigned to the “no” or "little value" categories. The Community Cloud was trailing the list with 32% "no value" ratings (Figure 6).

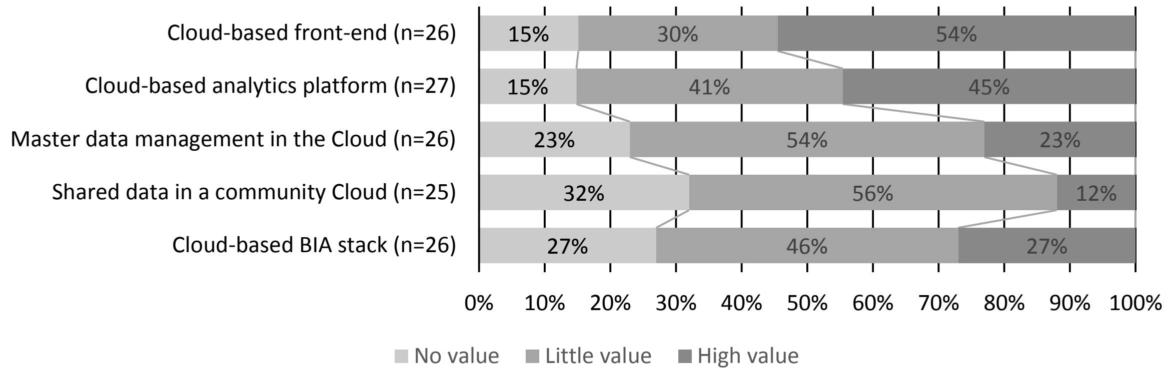

Figure 6. Value of Cloud BIA applications

The questions on feasibility revealed a similar picture (Figure 7). The participants rated the front-end and the analytics platform as more likely to be implemented than the other three scenarios. Notable is that every second participant considered a Community Cloud as *not feasible at all*. Even the feasibility of an entire Cloud-based BIA stack was rated higher than the Community Cloud scenario which came as a surprise for us.

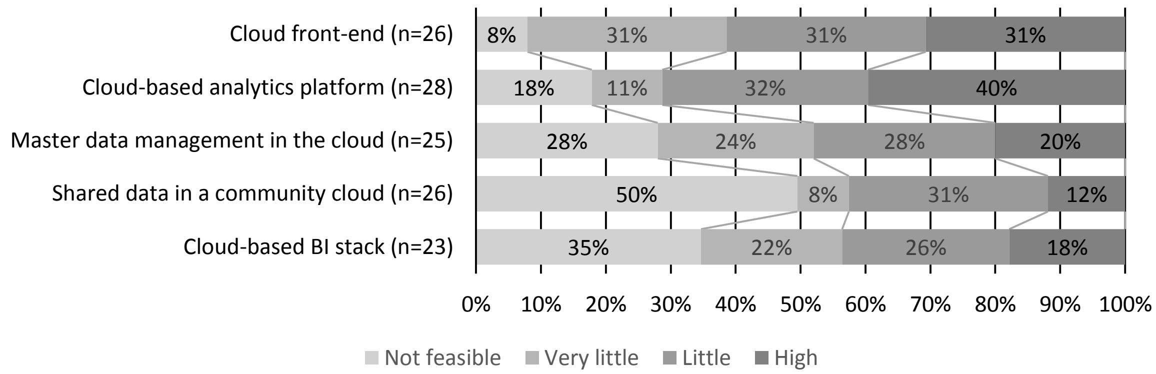

Figure 7. Feasibility of the Cloud BIA applications

In the course of the survey, we also asked the attendees to rate the importance of several potential success factors (derived from the case study) on BIA outsourcing decisions in their firms. At this point, we first concentrated on General BIA outsourcing decisions rather than already discussing the special case of Cloud Computing. The participants stated that besides common outsourcing criteria (e.g. strategic relevance) technical interfaces, organizational and content dependencies, or the degree of individualization of a system play an important or even critical role to them. Interestingly, unlike the experts in the case study, the respondents did not deem the integration in service management structures or the handling of change requests as critical factors (Figure 8).

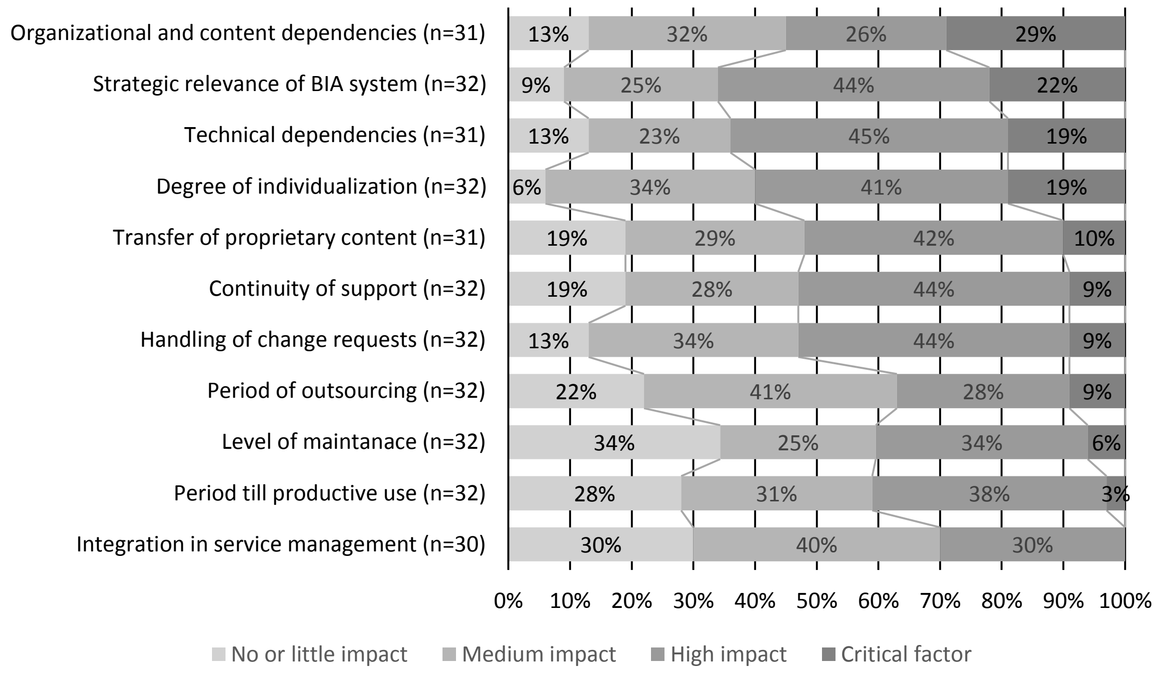

Figure 8. Potential success factors of BIA outsourcing decision

Additionally, the participants were asked to rate critical success factors with respect to their relevance for each of the discussed applications. It turned out that throughout the scenarios, the participants classified legal and contractual requirements as highly important. Furthermore, technical and organizational dependencies as well as the degree of individualization were repeatedly among the most important factors. Unfortunately, there were not enough responses to clearly identify further insights.

5 DISCUSSION

The results indicate that there is a certain interest in the topic Cloud BIA. The results also illustrate that and why Cloud Computing currently is not yet reasonable for all approaches. Both the interviewed experts as well as the participants of the survey saw little value in the idea of a completely Cloud-based BIA stack, similarly the Community Cloud was especially met with strong skepticism.

The survey results correspond with the statements from the case study, where both experts and users stated that at the present state there is no advantage in moving an entire BIA infrastructure into the Cloud. It seems that the value of Cloud BIA applications currently lays in more specific use cases. Accordingly, the ideas of a Cloud-based front-end tool or a Cloud analytics platform reached the highest value and feasibility ratings. This raises the question of what makes an application more or less suitable for Cloud BIA.

A front-end tool only adds a self-contained additional layer on top of an existing infrastructure; the analytics platform depicts a more or less isolated and temporary solution. Both scenarios have a limited scope and encompass tools that do not need a tight and complex integration with the rest of the BIA landscape. In contrast, the scenario of a Community Cloud or an entire BIA stack does not only have larger scopes but also comes with more dependencies. The scope and the associated integration complexity can therefore be considered of particular relevance. This assumption is also supported by the finding that most factors with a high impact on BIA outsourcing decisions are closely related to the integration complexity, e.g. organizational and technical dependencies or the degree of individualization of a system.

Furthermore, the participants rated the feasibility of implementing Cloud-based master data management services, a Community Cloud or an entire Cloud BIA stack as being limited at best. Since security and privacy are major concerns of Cloud Computing and many participants mentioned laws and regulations to be critical factors, the poor feasibility probably results from the data-intensity of these scenarios. Of course, all types of applications can contain critical business data. The data in a specific front-end or an isolated analytics platform is probably conceived to be easier controlled and contained than in scenarios with a wider scope and multiple systems.

Another finding of the research is the importance of *organizational factors* in the context of Cloud BIA, particular with respect to IT Service Management procedures. Both in general BIA outsourcing decisions and in the context of the specific applications, the participants continuously attributed high relevance to organizational and content dependencies. In several cases they rated them even higher than technical dependencies. This indicates that a solely technical perspective is not sufficient to evaluate a Cloud BIA scenario and that aspects of organizational and ITSM compatibility are still underrepresented in the current Cloud BIA discussion.

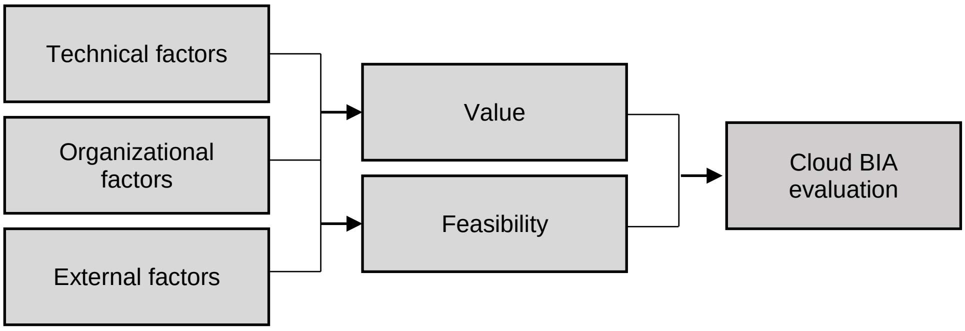

Figure 9. Holistic evaluation approach of Cloud BIA applications

Figure 9 summarizes our findings. From a theoretical standpoint, this is in line with general IS theory (Galliers & Land 1987), particularly with the TOM-framework (Tornatzky et al. 1990). In the Cloud BIA case, *technical factors* subsume all aspects in relation to the infrastructure, interfaces, and issues like the individualization of a solution or the volatility of workloads for data extraction, transformation, and processing. The *organizational factors* include aspects of organizational structure and processes (particularly from the realm of ITSM) as well as content dependencies, internal regulations and compliance rules. At last the *external factors* comprise the environment conditions like laws and regulations or the availability of suitable solutions and reliable partners. The combination of these factors affect both the value of a Cloud BIA application for a company as well as the actual feasibility to implement it.

6 CONCLUSION AND OUTLOOK

The research clearly illustrated that viable applications for Cloud-based BIA can indeed exist. But it also disclosed that the Cloud is not a universal remedy for all issues in BIA and that it is currently not yet suited for all scenarios, even if they might be valuable.

The examination of the different applications showed that experts currently see a higher value contribution and a greater feasibility for more specific and isolated applications, like a single front-end or an isolated analytics platform. More extensive applications like a Community Cloud or an entire Cloud-based BIA stack are still considered problematic. As reasons for that we identified *firstly* the scope of a scenario, *secondly* the integration complexity, and *thirdly* concerns about security and privacy.

The analysis of the criteria for BIA outsourcing decisions as well as relevant factors related to the applications revealed the importance of organizational and external aspects in the context of Cloud

BIA. Hence, we suggest a broad perspective that combines technical, organizational and external factors (in accordance to proven approaches like the TOM framework) when evaluating a Cloud BIA application.

The limitations of the study mainly lie in the small sample size – a result that we consider to be a by-product of the negative developments regarding the Cloud subject in general during the period we conducted the study (NSA case). This is why our results need to be considered as first indicators only – although the triangulation with the case study does support their validity.

In summary, the research results speak against the idea of a complete outsourcing of BIA to the Cloud. It seems more likely that Cloud Computing finds its way into today's BIA infrastructures through specialized applications and hybrid approaches where Cloud-based components complement existing on-premise structures. However, a shift in favor of Cloud sourcing becomes conceivable as soon as main challenges like the integration complexity and security concerns are diminished by technical and regulative standards and best-practices.

Additionally, it needs to be pointed out that the results also indicate a higher inclination to apply Cloud BIA for smaller enterprises – where a smaller degree of complexity meets a lower availability of personnel and technical resources. In this context, another interesting approach would be to particularly address companies with no full-fledged BIA application in place as well as application areas where BIA is not as widespread yet (e.g. BIA solutions for more engineering-oriented areas in manufacturing and logistics). Eventually, the subject of Big Data brings in new tools and tasks and strengthens the role of external data and therefore solution provision approaches.

This work contributes to the academic field of BIA research with insights about the adaption process of Cloud-based solutions as well as with concrete applications that illustrate current possibilities and limitations. The applications can on the one hand serve as a fundament for further examinations and on the other hand they might facilitate a more focused approach to the discussion of Cloud BIA in practice.

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