ERP as Software-as-a-Service: Factors Depicting Large Enterprises Cloud Adoption

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Abstract. Cloud computing has shifted the paradigm from developing enterprise software to acquiring it as a service. While supportive information systems have rapidly transformed to Software-as-a-Service (SaaS) solutions, mission-critical ERP's largely remain in more conventional operation models. Especially with SAP ERP systems utilized by large enterprises, adoption to public cloud-based SaaS ERP has been slow and on-premise ERP is still thriving. Based on a multi-case study interviewing six large enterprises, we identified four elementary factors which affect cloud adoption for mission-critical ERP's. The findings indicate that service quality and costs are the most significant factors influencing SaaS adoption, while technical limitations and cloud characteristics are also identified as key factors.

Keywords: Software-as-a-Service · SaaS · Enterprise resource planning · Cloud computing · Cloud transformation · SAP · ERP

1 Introduction

Cloud computing offers a novel approach to the utilization and ownership of information systems (IS) and the use of cloud solutions has increased rapidly during the past decade. Cloud computing has practically revolutionized the way software is utilized by enabling the use of information technology as a commodity [1, 2]. Software-as-a-service (SaaS) cloud service model offers many benefits, the vendor installs the software on its own equipment and is fully responsible for updates and development efforts. Essentially, cloud computing transforms software acquisition into service acquisition [3] where cloud computing resembles software renting instead of purchasing [4].

Whether an information system is implemented as a traditional on-premise system or acquired as a service from the cloud, the company's requirements for the system should remain the same. ERP systems play a very central role in business operations, as they are responsible for day-to-day operational activities [5]. For business customers, the cloud seems like an attractive solution. Cloud computing promises a fully outsourced, elastic service model which can be priced according to use [6, 7]. This may be easier and more cost-effective especially for SMEs. While small companies are more flexible in their needs, large companies typically require tailored solutions, especially if they are

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replacing mission-critical systems [8]. ERP systems are also impacted with high switching costs between software vendors, which can also help to protect a SaaS providers position and pricing [4, 18]. Cloud has some limitations due to its nature, e.g. privacy concerns can prevent adoption as a company's sensitive business data would be entirely on the responsibility of the cloud service provider [9, 12], also software customizing options can be limited [12]. Cloud technology migration may also involve significant costs for enterprises [10].

Although cloud computing has been on the rise for the past decade within many areas, SaaS ERP solutions for large enterprises core systems is still a recent phenomenon. Previous research on cloud computing has shown little interest in ERP specific factors that would apply to the cloud paradigm [11]. Some academic researchers suggest that cloud ERPs could benefit from lower implementation costs, faster deployment, usability, availability of new technology, as well as frequently deployed upgrades and version changes [12]. Others have shown inconsistencies between the findings of different researchers; for example, performance and security issues were seen in other studies as risk factors for cloud computing [13], in some studies these factors are an explicit benefit to the cloud [14]. It has been suggested that SaaS ERP will eventually be implemented by large companies [26], yet this still seems waiting for realization.

We thus identify a research gap in previous literature on explaining why large enterprises still seem reluctant to move their mission-critical SAP ERP systems to public cloud SaaS, especially when SME's SaaS ERP adoption rates are high. Thus, the research question for this article is defined as "Which factors affect large enterprises SaaS ERP adoption for mission-critical systems?" This article seeks to clarify these issues and contribute to the IS field of research by exploring how large enterprises are operating SaaS ERP solutions as compared to traditional on-premise solutions. The aim of this study is also to understand whether the transition to a SaaS ERP also realizes the benefits that are generally presented for cloud services. While there are different delivery models for cloud services, such as public and private cloud for the deployment model or infrastructure-as-a-service and platform-as-a-service for cloud service models [6], we specifically focus this research on public cloud SaaS ERP systems to understand their significant differences to the currently exploited service models of large companies on-premise ERP systems.

2 Literature Review

To form a basis for the empirical research, we conducted a literature review with systematicity and rigor [40] on previous research in order recognize the describing factors between public cloud SaaS ERP and the traditional on-premise service models. Based on the synthesis of existing literature we construct a simplified framework of the defining areas between these service models, in order to adopt our empirical analysis on SaaS for large companies. Existing literature was systematically searched from the academic databases ACM Digital Library and IEEE Xplore, while Google Scholar search engine was also used in a supportive role. We used search terms such as "cloud computing", "cloud ERP" and "SaaS ERP", all relevant papers and articles were reviewed rigorously to improve quality [41].

On-premise systems are information system which are installed and managed by the customer, through internal or external resources. A company must acquire all the required infrastructure, the determining factor being that the management of the system is in the company's own hands. Service production can be outsourced, but ultimately the company decides how it will develop the system [15]. In public cloud SaaS systems, the company leases the information system. The service provider acquires the infrastructure and implements the information system for the use of the customer, who pays a monthly rent to utilize the system. The fee includes license, i.e. access to the system, as well as to the infrastructure under it [3, 32]. The acquisition or development of an on-premise system requires a large initial investment, e.g. in the infrastructure whereas in the cloud, the system is subscribed as a service [16].

Traditionally ERP systems have been installed as on-premise systems, running and operated on conventional data centers close to the organization [19]. The acquisition or development of an on-premise system requires a large initial investment in e.g. the underlying infrastructure, whereas in the cloud the system is made available as a service [16]. SaaS vendors acquire the required infrastructure and implement the system, where customers pay subscription fees for usage [3, 31]. Some of the perceived risks associated with using SaaS cloud services are related to security [9, 33], especially with ERP systems as they contain sensitive business data. The technical implementation of security measures is increasingly in the responsibility of the cloud service provider. SaaS service providers also share resources between several different clients, which propose new challenges to the traditional concept of security [17, 20].

From a cost perspective, cloud services are expected to be more affordable due to the economies of scale that the service providers can pass on to their customers. However, large companies might not benefit from this as they have specific and complex needs [21]. Cloud services provide continuous development in the form of software updates [3], which should be noted when considering the total cost of ownership for IS [22]. Licensing models also differ between on-premise and cloud systems. On-premise software licenses are typically perpetual by nature, while SaaS licenses are subscriptions that are valid for as long as the customer keeps paying for the monthly fees. Lifecycle investments also follow a different approach, on-premise systems require recurring investments in version upgrades and new infrastructure, while these are all covered by SaaS subscriptions in the cloud [3, 11, 23]. ERP customization options are a key issue from the business process perspective. Typically customizing options are more extensive with on-premise systems, where SaaS systems only offer limited customizing possibilities [24, 25].

Cloud performance and availability may also differ from an on-premise system. Previous research has shown conflicting results in this regard, as some see performance and availability as an advantage for the cloud while others view this as a risk [9, 13, 14, 30]. One of the characteristics of cloud service is the continuous development, which brings new functionalities to the customer. New innovations are frequently rolled out to the system, customers no longer need to conduct technical version upgrades [3].

The most mission critical IS are usually reluctant to move to the cloud. Cloud solutions per se should not be a self-sufficient solution, but cloud migrations are expected to produce concrete benefits [5]. Business applications which are not mission critical are usually seen as a more natural choice for cloud migration [15]. Business applications like

CRM and office suites are already showing high SaaS adoption rates for small and large companies [27]. Even specialized niche market software has increased interest in consuming SaaS model [34], but SaaS ERP adoption remains low [27]. While the existing literature has widely studied SaaS ERP adoption for SMEs [8, 28–30], similar studies for large enterprises distinct adoption are sparse. Some researchers suggest that large enterprises SaaS ERP adoption may be hindered by complex implementations [4, 21, 27], expensive subscription fees due to large user base and multiple modules [21], organizational resistance [21] or security and reliability issues [21, 27]. Previous research also identifies the need for more in-depth studies specifically on large companies SaaS adoption [21].

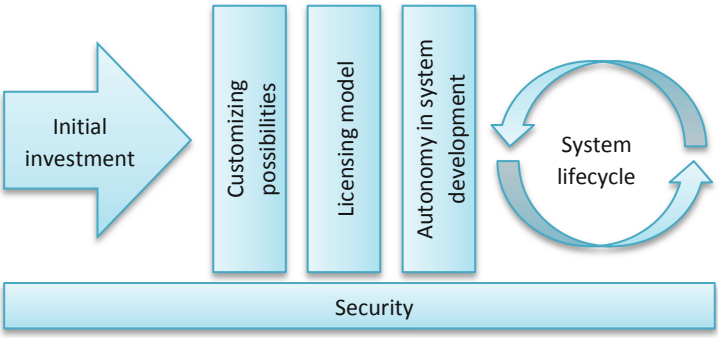

Fig. 1. Framework for on-premise IS and SaaS IS differences.

SaaS services thus have certain, clearly distinguishable characteristics from on-premise systems (Fig. 1). This provides benefits to the customer, but it can also be a limitation for companies that need precisely tailored solutions for their own business processes. SaaS and on-premise systems therefore have their own potentials, strengths and weaknesses. We propose a framework for describing the essential characteristics between on-premise IS and SaaS IS. Implementing an information system begins with an *initial investment*, where on-premise IS typically require a more substantial investment due to hardware purchases and system installations. SaaS vendors provide all the required components as a service, leading to a smaller initial investment [3, 15, 16, 31, 32].

The characteristics depict how the system is utilized and operated by the customer. *Customizing possibilities* reflect the flexibility of the system and how individually it can be configured to respond to distinct business demands. On-premise systems typically have a high amount of customizing possibilities, where the system can be tailored to be fit-for-purpose. SaaS vendors limit the customizing options in order to provide a more limited IS template for multiple customers, while still following industry best-practices for business processes [24, 25]. *Licensing model* differentiates the system operational models as well. On-premise systems are commonly following a perpetual licensing model, where customers can use the purchased software for as long as they want to. SaaS systems, however, are based on a subscription licensing model where the customer

is renting the software for a specific amount of time. While the SaaS system is being utilized, the monthly licensing costs keep adding up [3, 11, 23].

Autonomy in systems development is describing how the IS development itself can be controlled by the customer. On-premise systems give more autonomy as a service model, where customers can decide to develop new features and operate the system solely through their own resources or outsource these tasks to an external service provide. SaaS vendors, on the other hand, are more independently developing the system for multiple customers simultaneously, who have less autonomy to align on the development of new features [16, 19].

System Lifecycle refers to the maintenance of the IS, such as commencing version upgrades, updating the system and performance tuning. On-premise systems typically embrace heavy and expensive upgrade projects, which are executed rarely or infrequently due to their size and the involved costs. SaaS systems incorporate these as part of the service model, upgrades are more frequent and require less effort, thus the customer can benefit from continuous digital innovations [3, 12, 16].

Finally, *Security* is a crucial part of any IS regardless of their service models, which should be considered in all parts of IS. Again, on-premise systems require the customer to apply frequent security patches on many different components, while SaaS vendors are responsible for the majority of these requirements in the cloud. On the other hand, SaaS customers are typically sharing at least certain underlying resources which presents different technical security aspects as well as concerns for potential security breaches [9, 17, 20, 33].

3 Research Method

As the research question was defined to focus on large enterprises cloud ERP adoption, we selected a case study research method for this paper. Case studies examine real events and obtain a wide range of information for this purpose, their strength is in explaining how or why a phenomenon has occurred [35, 36]. The research was conducted as a multiple case study as the phenomena was seen diverse by nature, requiring cross-case comparison between different enterprises [37]. We interviewed six different persons from six large companies, where the common denominator was a large implementation of SAP ERP on-premise systems responsible for the company's core business processes, but also experiences from SAP's SaaS cloud services. The interviewees were randomly selected from the participants of a technology seminar, the selection criteria required practical experiences from transferring on-premise SAP systems to a SaaS-based cloud service, so that the collected data would be able to answer the research question. The sample provided a diverse view of the experiences of large companies utilizing SAP ERP as their mission-critical IS.

Interviews were conducted both face-to-face and via Teams, following a semi-structured interview format. The list of interview questions was provided to the participants for prior acquaintance by e-mail so that everyone had the opportunity to prepare for the topics of the interview. Notes were handwritten and transcribed immediately after the interview. The transcribed interviews were subsequently sent to the interviewees by e-mail, giving participants the opportunity to correct any errors or misunderstandings.

About half of the interviewees returned to these and made minor edits to the transcribed text, which helped increase the validity of the material. The actual interviews lasted 30–60 minutes per interviewee. Following the semi-structured formula, ten questions were discussed with the interviewees, allowing further questions to be clarified according to the answers as well as sprawling outside the question area. A total of 24 pages of transcribed data was collected. In the analysis phase, the data was coded while reflecting on the research questions. The analysis of the data was following a three-step model, by first reducing the data, creating displays of the data, then drawing conclusions and verifications [42, 43]. Computer assistance was utilized to organize and code the data in support of the analysis [38]. Analysis was carried out by coding the material initially in a word processor, then running a Python script which extracted all the codings into a spreadsheet program [39]. This was continued by organizing the material and deriving themes from it.

All interviewees had long work experience in the IT industry, as well as several years of experience in utilizing cloud services. The interviewees had served in various roles during their careers, for example as developers, project managers and architects. Their views provided a diverse picture of large companies' business-critical systems with recent experiences on utilizing cloud services on a large scale. The interviewees details are described in Table 1 below.

Table 1. Background information for the interviewees.

Interviewee	Work experience	Cloud experience	Industry	Company size (employees)	ERP role
A	15 years	3 years	Manufacturing	>5 000	Client
B	16 years	4 years	Manufacturing	>15 000	Client
C	25 years	5 years	Manufacturing	>15 000	Client
D	20 years	3 years	Public sector	>5 000	Client
E	20 years	3 years	Public sector	>5 000	Client
F	25 years	7 years	Consulting	>100	Partner

The role of the company describes the relationship with SAP. All of the companies utilized SAP systems in their core business and where perceived as customers for SAP. However, interviewee F represented a consulting partner for SAP that implemented SAP systems and provided consulting to client companies. The experiences of interviewees A-E were thus based on customer role for SAP ERP and the day-to-day operational use of the system, while the experiences of interviewee F were based on the expert experience from numerous different customer implementation projects.

4 Results

Based on the analysis of the data, four topics were formed to describe the main factors affecting SaaS ERP adoption: service quality, costs, technical limitations and cloud

characteristics. Service quality was considered to include features which were influencing business continuity via the information system. The topics reflected the differences between on-premise and SaaS ERP systems, while also answering why large enterprises continue running their mission-critical systems on-premises. The analysis implied these as the most important factors, as depicted in Fig. 2 below.

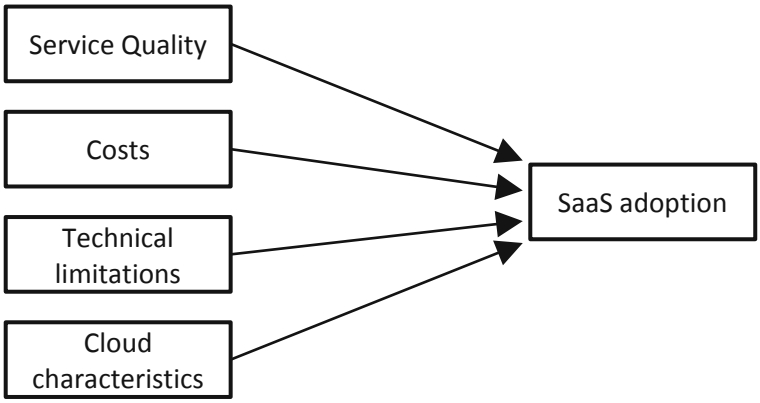

Fig. 2. Factors affecting SaaS ERP adoption.

4.1 Service Quality

The service quality of mission-critical systems is fundamentally important, as large enterprises are utilizing IS in their core operations. There were mixed experiences with the service quality and reliability of SaaS ERP between the interviewees, where the majority felt that the level of service and reliability had deteriorated significantly when compared to the on-premise system while some saw the SaaS system as stable and reliable. This was dependent on the experienced service level of the previous on-premise system: companies which were unhappy with the preceding systems quality were content with SaaS service quality, and vice versa. If the old on-premise system had been unstable, the customer may experience even a small improvement as a major benefit that was achieved via SaaS adoption. However, large companies tend to have made major investments in the service quality of their business-critical on-premise ERP systems in order to maximize availability. Thus, the quality of service in a SaaS system may appear to be significantly lower for them. Overall, the results indicate that service quality for SaaS ERP systems may be lower than what large companies are accustomed to with their on-premise systems.

> "*The quality of service has sometimes varied. There has been some more downtime, but the system has also recovered quickly.*" (Interviewee E)

> "*Some customers have criticized cloud performance ... SaaS has had worse performance than on-premise systems. Most of the time the applications have functioned at least satisfactorily, but the problem is that there is no recipient for performance problems when they have occurred.*" (Interviewee F)

On-premise systems were hence seen as more reliable than their cloud counterparts. However, in terms of incident handling and application support, SAP's own service level was perceived to be similar in both systems. Issues which required SAP's direct input were thus equal by nature. Regarding vendor related issues, personal support was seen as an advantage of on-premise systems because the enterprise knows which data centre their systems are physically located in but also who actually maintains them. There can even be personal relations and familiar support personnel to call in case of a n problem, instead of a faceless incident handling process:

"*On-premise has been more stable on these ... SAP's support services for the cloud itself are exactly the same as for on-premise products: you create a ticket for a problem and hope that someone will handle it.*" (Interviewee B)

"*With traditional on-premise models, the customer has a personal relationship to the operator. The company usually knows who to contact if things don't work out, which makes corrections faster.*" (Interviewee F)

SaaS ERP may not be suitable for all enterprise customers, but the transition of services to the cloud could still be an otherwise ongoing trend. The service model for future information systems may possibly reside in hybrid models, where some of the systems are acquired as ready-made services while some core system functionalities are kept more in self-managed or hosted on-premise solutions:

"*SaaS will never work for all companies, it will fit some better than the others. A full cloud transition is unlikely to ever happen.*" (Interviewee F)

The service quality of mission-critical information systems is strongly influenced by the content of service level agreements (SLA), which determine the availability of the system and the possible sanction for breaching the SLA. In this regard, SaaS SLAs were seen as too weak for large companies' mission-critical systems. Unplanned downtime of SaaS was seen as a clear barrier to adoption, while vendor support from SAP was also seen too weak for a critical system. This indicates that the quality of service of the SaaS system is an important factor which influences large companies' business-critical SaaS ERP adoption. SaaS ERP was seen as more suitable for SMEs, or to information systems which are running non-urgent supportive functions. In the current state, the quality of the SaaS ERP service provided by SAP is not sufficient.

"*Based on my experiences, I would see that unplanned downtime and monitoring issues are the main reasons why this is not fit for mission-critical applications.*" (Interviewee B)

"*The quality of the service largely depends on how well the service level agreement is defined on paper.*" (Interviewee C)

"*Service level agreements are too lax, and most users are probably already aware of the challenges with SAP support. In my view, at least these factors have the greatest impact on why business-critical applications will not move to the cloud in the near future.*" (Interviewee E)

4.2 Costs

The second topic that emerged from the interviews were information system costs. This includes costs incurred in different ways that directly or indirectly affect the total cost of ownership. Information system costs were seen to include e.g. licenses, personnel costs, consulting costs, hardware, system deployment, development upgrades, and testing. Cost structures were reflected from the SaaS systems which were used by the interviewees, while comparing to their preceding on-premise counterparts.

SaaS costs were considered to include the costs related to the implementation, operation and development of the system. Directly involved costs were estimated to be at approximately the same level in SaaS systems when compared to the preceding on-premise system. The implementation effort of deploying the system was also seen to be at the same level as in the old system, as SaaS ERP needs to be configured to the company's requirements. Deployment costs are also case-specific and depend on the enterprise specific requirements, meaning that these costs may move in either direction when compared to on-premise. The implementation effort in a SaaS system was seen to be different by nature but involving an equal amount of time and matter. For example, system installation work is minimal and technical deployment is fast but deploying business process specific functionalities requires an equal amount of workshops and requirement planning as previously.

> "*There was no large difference in the amount of work for implementing the system when compared to the implementation of the on-premise system ... The costs have supposedly remained the same.*" (Interviewee A)

> "*We didn't need to do any installations by ourselves. For servers, this was cheaper. ... I've operated the previous on-premise version and this is much easier in the cloud, where all basic configurations were ready out-of-the-box ... On our usage level the total costs have virtually remained unchanged.*" (Interviewee B)

SaaS may not be a cost-effective alternative either to running an own data centre solution or to a hosted Infrastructure-as-a-Service solution. If a company has already invested extensively in its own servers and infrastructure or in an IaaS provider, similar costs in SaaS may even be much higher. Focusing and tendering large platform contracts may give more significant overall discounts due to economies of scale, than what is realizing to the customer side from SaaS ERP. SaaS cost benefits are more present in the amount of required consulting hours for functional development. Thus, SaaS cloud systems have some advantages in terms of investment planning and the amount of required labour:

> "*As an investment, the cloud has been much clearer. In my opinion the investment plans have been more accurate than with on-premise... I would say that the difference is really noticeable in how much the system requires outsourced consultants or our own work. The cloud is therefore clearly producing results in this respect.*" (Interviewee D)

In general, comparing the operating costs between on-premise and SaaS systems is not easy due to the differences in their characteristics. The systems are developed

through different models, so the cost benefits depend partially on exploiting each models' benefits. The operating costs of a SaaS ERP may still be higher for large enterprises than with an on-premise system.

> "*The cost of operating a cloud ERP will eventually reach the same level, even if it doesn't require an initial investment. However, there is no single answer to which one is more cost efficient as a whole ... It's difficult to say whether cloud is actually able to save on costs, because it's hard to compare to on-premise costs.*" (Interviewee F)

Comparing the total cost of cloud to that of an on-premise system is, in many respects, difficult. For many large companies, SaaS ERP's experiences are limited in both time and quantity. Additionally, past on-premise costs have often not been tracked at an exact level, such as the tracking the accumulated personnel and server costs. This also makes it difficult to compare total costs between these systems. On the other hand, the mere cost of SaaS and on-premise should not be directly compared because the service model itself is different:

> "*Admittedly, it is difficult to compare these because we have had many more on-premise systems and they have contained more functionality.*" (Interviewee D)
>
> "*It may be a little difficult to compare the costs when they are so different ... However, this is not just about the costs, but about a different model of service production.*" (Interviewee E)

The meaningfulness of cost comparison is affected by the fundamental difference between a SaaS system and an on-premise system. SaaS is intended to be implemented in a more standardized format, while on-premise systems have been freely customizable by the customer. However, free customization possibilities are not just a positive thing:

> "*This is really a question about comparing apples to oranges. Traditionally customers on-premise SAPs have been fully tailored to meet customer specific needs, which in turn has led to implementation projects reaching a certain size and appearance.*" (Interviewee F)

4.3 Technical Limitations

SaaS also has certain technical limitations. Because various technical components of the public cloud service are entirely in the hands of the supplier, the customer does not always have the possibility to influence all the relevant functions which they have come accustomed to. Network latency was seen as one of the potentially limiting factors, as the data centres operating the cloud services platform are usually farther away from the customer than the customer's own data centres. This can pose challenges for industrial automation systems, for example, whose latency requirements can be very stringent:

> "*Latency problems are also a major problem because large companies have a network of systems which produce their core functionalities. If ERP is in the cloud*

and the legacy systems remain on-premise, the latency can be intolerable especially with business-critical integrations" (Interviewee C)

"*SAP has decided in all their wisdom that the session timeout is 20 minutes which cannot be changed. Then there are tasks that take longer to complete, but the application discards the data if the session has expired.*" (Interviewee B)

The customizing capabilities of the cloud service is one common limitation for customers, which is also widely identified in the previous literature. The customizability of a SaaS system is more limited than in an on-premises because the same system is offered to multiple customers. This is especially significant for large companies, who have widely customized solutions fit for their specific business processes.

"*At least one vast problem that we have encountered is with customizations.*" (Interviewee B).

"*Certain things could not be implemented in the cloud, so we decided to utilize a hybrid model and implement these things on the on-premise side ... Otherwise, the functionalities could be implemented from the service as-is, we use these processes now in for example induction.*" (Interviewee D)

Although limited customization appears to be a restriction for SaaS ERP, it can also be seen as an advantage specifically in leveraging industry standard best-practice business processes, rather than tailoring the system extensively to fit self-developed requirements.

"*The implementation of a cloud system is first and foremost about the organizational change processes and what the company wants to do in terms of its own business processes. In other words, will the information system be adapted to fit the business processes, or the processes themselves adapted to standard solutions that are readily available in the system.*" (Interviewee A)

"*The implementation of a SaaS system requires the company to make both process changes and changes in various operational methods. It requires a completely different way of working, not just moving from on-premise to the cloud ... Operatively it isn't sustainable if a large number of tailoring is desired.*" (Interviewee F)

The fitness for purpose of the information system is important for customers, i.e. how well the system meets the company's requirements. This is not just a question of the system's customizability, but more generally about the functionalities contained in the system and the flexibility of implementation. From an ERP perspective, a SaaS solution may not be suitable for the mission-critical system of large enterprises due to the limitations in customization capabilities. SaaS ERP can be seen as more suitable as an SME solution for which standard solutions are more likely to be sufficient. In practice, a SaaS ERP system is not able to provide sufficiently flexible solutions for specialized industries. Above all, there is a lack of flexibility and the system is not able to meet the requirements. These technical limitations of SaaS ERP are therefore preventing adoption for large companies.

"*For a small company SaaS is a good solution, as long as you can suffice to a standard solution and configurations. However, for the core business of large*

companies this is not yet mature, I don't see that a global ERP system could be completely provided from cloud." (Interviewee C)

"*For our business-critical systems, I don't see this as possible. They are just too industry-centric.*" (Interviewee D)

Information security is an integral part of the service production of enterprise information systems, both in SaaS and on-premise systems. Security requirements have also been presented in previous literature as a restriction on the adoption of SaaS ERP. However, the interviewees did not perceive security issues as a major concern or a preventing factor. The companies had a high level of confidence in the supplier's expertise in proper technical information security. Security practices were seen as part of normal system development, which is addressed as a separate part of the implementation project. The amount of work required on information security in utilizing a SaaS service may depend on the degree of maturity of the solutions used by a company. Many large companies have already done numerous evaluations and preparations in advance, in order to understand what technical measures are required from them to utilize SaaS systems.

"*We have done a lot of work regarding information security. This has been contingency planning and investigating different solutions which has been carried out both in-house and via benchmarking.*" (Interviewee D)

Security issues were seen as important technical aspects on leveraging a SaaS system, this perspective is slightly different for customers than with on-premise systems previously. In on-premise systems, security requires more investments in physical and technical components, these are typically elements inside a company's own intranet. With SaaS systems, security is more as an application-side factor for the customers as technical security features will be administered by the vendor.

"*For browser-based applications the security measures are provided by the SaaS vendor. Typically, investments in security are physical things like firewalls and technical hardenings, but these differ from application security.*" (Interviewee F)

4.4 Cloud Characteristics

SaaS end-user satisfaction is clearly a positive factor. Also, SaaS systems can be further customized by in-house super users without external consultant resources. Ease of use and new technological benefits, such as mobile use of the system, are the most common benefits of cloud ERP. In this sense business applications start to resemble consumer applications, where usability improvements are frequent.

"*The most important aspects which have brought user satisfaction are accessibility, mobile applications, and ease of use. Our business has been satisfied with the system and its processes, although it has had to modify its own processes.*" (Interviewee C)

"*The new system has been very beneficial and easy to use. This is primarily due to the fact that there was previously no desire to upgrade our on-premise system earlier. With cloud ERP, the newer version was inevitably available. The newer*

version has introduced welcome improvements for business, for example in the form of ready-made automation or user-friendly interfaces." (Interviewee F)

One part of cloud characteristics are system upgrades. With on-premise systems, upgrades and version changes require extensive work and are heavier by nature than with SaaS. Upgrades are more frequent in SaaS ERP, allowing new features to be more readily available. As more frequent system upgrades are perceived as a strength for SaaS, the overall view of this is positive for customers:

"*The system is upgraded frequently which is good, there's no need to pay for version changes separately as in the old system.*" (Interviewee A)

"*New innovations in the system are more seen as positive than negative.*" (Interviewee D)

In addition to the perceived benefits of frequent technical updates, this also has its own challenges. The release cycle for SAP's cloud ERP system upgrades is usually four times a year, which many find unnecessarily frequent. Depending on the SaaS implementation, customers may be able to postpone upgrades up to a certain point. However, in some SaaS ERP systems the customers can't influence the upgrade schedules and they are forced to be rolled out to the customer systems via a predefined schedule. Practices vary between different products. This may also present a risk factor if frequent upgrades are combined with extensive customizations or extensions:

"*Upgrades to the SaaS system are frequent, for example quarterly. Any organization will be in trouble if it makes overly customized processes in the system.*" (Interviewee C)

An important aspect on technical upgrades is in the service delivery model of cloud ERP: there is a significant difference in terms of upgrades between public cloud and private cloud implementations. Companies face very differing options here, for example, in the ability to postpone upgrades or freedom on customizations which has a major impact on the customer experience also. Some customers have decided not to upgrade their private cloud environments at all because the service provider is not forcing these customers to do so. Business continuity is again important in this regard, which is why upgrades can also be seen as a risk:

"*On-premises upgrades can often be delayed because they are not mandatory ... The business continuity of any company itself is obviously more important than a single cloud application. The benefit of frequent upgrades is really case-specific.*" (Interviewee F)

The challenge of frequent upgrades is that their effects are reflected in the core functionalities utilized by the company. The upgrade must not break any core functionality, which may be more challenging with customer modifications in the cloud and external system integrations. This requires extensive testing from the customer side as companies need to validate their own critical functionalities affected by the cloud upgrades. This is easier to manage if the implementation of the system is as standard as possible and

testing efforts are properly resourced. Integrations are particularly crucial: if the cloud is integrated into an on-premise system, this part must always be tested simultaneously with cloud upgrades. The need for extensive testing due to technical cloud upgrades can thus be surprisingly wide, which can also generate excessive testing costs. Thus, the role of automated testing should be evaluated with SaaS ERP implementations. Workloads resulting from testing efforts were therefore perceived as a negative issue that was increasing with cloud ERP:

> "*We are forced to do extra work four times per year due to upgrades, which is perceived negatively. This means, for example, testing.*" (Interviewee D)
>
> "*All your own extensions and integrations are always required to be tested. The amount of testing has increased slightly.*" (Interviewee E)

The interviews were altogether reflecting well on the distinct requirements that large companies possess on their mission-critical ERP systems. Each recognized category was showing how these companies utilize information systems and which factors are relevant when considering SaaS adaption. Service quality, costs, technical limitations and cloud characteristics are all factors that need to be addressed by the SaaS vendor to support adoption or face the risk that SaaS ERP will remain as an SME specific phenomenon.

5 Discussion and Conclusions

As large enterprises rely their daily operations on these mission-critical systems, service quality is expected to be high. The availability of the cloud platform needs to match that of an on-premise system, while also service level agreements must convince large companies so that they are able to trust the service quality will fulfil their requirements. Experiences for the level of vendor support on incidents and the personality of support are also affecting the service quality, as previous negative experiences on vendor support can undermine SaaS adaption for mission-critical systems. The findings indicate that system availability is currently perceived higher in on-premise systems where large companies have made significant investments to guarantee high availability, while the having experienced SAP's SaaS ERP services to be more commonly plagued with unplanned downtime and subliminal support. Cloud ERP SLA's were implied to be inferior, while trust in the level of support from SAP was perceived as inflexible and anonymous. As business continuity was indicated of being one of the most important factors for large enterprises mission-critical ERP systems, the perceived service quality of SaaS ERP is currently preventing adoption for these companies. Previous literature has identified system availability and reliability as a challenge in implementing SaaS ERP [see e.g. 30], our research shows that large enterprises consider this as a key factor which affects SaaS adoption for mission-critical ERP systems. Supportive systems, such as HCM or CRM, may tolerate lower service quality as they are typically non-critical systems with lower impact on business continuity. As large enterprises have already widely adopted systems such as cloud CRM but remain reluctant on adopting core ERP as SaaS [27], these findings also help to explain this phenomenon.

Costs were the second identified factor in this paper. Comparing the costs between on-premise and SaaS ERP systems was noted to be difficult, as they are different by

nature and direct comparisons are not always possible. However, the overall indication was that SaaS ERP will not bring any cost benefits for large companies: even with no upfront investments in SaaS ERP the total cost of ownership is expected to remain on the same level as with on-premise systems. Over time SaaS ERP may even cost more, as the higher monthly payments accumulate. Thus, any cost benefit that has been suggested for cloud ERP by previous research [5] was absent in this study. Some academics have also proposed that SaaS ERP may be more expensive for large enterprises as they use multiple modules and have a large number of users [21]. We agree that expensive costs are an adoption factor here but also conclude that this is more related to SaaS pricing strategies than the amount of use. None of the interviewed companies were using a pay-per-use model, as they had negotiated longer contracts with larger discounts based on their business volume. Still, the costs were indicated to be at least on the same lever or even higher over time than operating similar functions and user volumes in an on-premise system. As most of the interviewed companies were outsourcing their on-premise systems operations to external partners, this would indicate that either IT companies which offer SAP platform operations are able to provide customer exclusive ERP systems more cost-effectively than SAP's public cloud offerings, or that SAP is charging a significantly higher profit margin for cloud capacity. Whatever cost benefits there might exist from the economies of scale behind SAP's vast cloud operations capacity, it seems to be not passing on to the customers side. The results also indicated that SaaS ERP implementation is comparably large as an effort to an on-premise ERP implementation. This affects vendor lock-in as depicted by [4], since cloud ERP is not practical to be rented for a short time at least in the scope of large enterprises.

Technical limitations are also a key factor which affects SaaS ERP adoption. For example, network latency is a clearly measurable technical limitation that may prevent SaaS adoption. Especially large enterprises utilize certain information systems that require low latency, such as systems that control heavily automated assembly lines or warehouses. Thus, latency can be a direct obstacle which prevents a company from adopting SaaS ERP, as latency sensitive systems like on-site automation devices may restrict how far away the ERP system can physically be located. While network latency is relatively easy to measure and define a technical requirement that a SaaS system must meet, customization limitations may be much harder to evaluate. Although customization possibilities are clearly more limited with public cloud SaaS ERP than in on-premise, these processes are based on industry best-practices while on-premise systems are typically more tailored to customers own process definitions [24]. Customization limitations should also be considered as a question of how the company is able to leverage competitive advantage from heavily tailored ERP processes. A generic SaaS ERP template will better fit processes where heavy customization would only bring low added value or differentiation from competitors. This may also help to explain why SME's have more widely adapted SaaS ERP, as they may be more content with the out-of-the-box business processes. Large enterprises views are thus somewhat different on SaaS ERP adoption than SME's, which is natural as their requirements and resources are considerably different. SaaS adoption for large enterprises may be a more peculiar phenomenon, as the companies are mostly running on-premise systems which are tailored to create added value and competitive advantages for their core business processes. When a company

is already running their own streamlined business processes in a tailored ERP system, it can be perceived as a significant risk to change the way of working in order to fit the predefined processes of SaaS ERP. We conclude that for large companies, SaaS ERP may be more suitable on business processes that are not mission-critical or providing a competitive advantage for the company.

Information security is also a technical limitation that can affect cloud adoption [9, 21], however our results indicate that large companies seem well prepared for cloud related security challenges and their trust in cloud vendors technical capabilities are high. Security was perceived as part of the implementation phase, which needs to be addressed with rigor like any other technical area. While some researchers have proposed cloud insecurity of being the main concern for large companies preventing cloud ERP adoption [21], we perceive security issues as technical tasks which are covered before or during the system implementation. From a technical point of view, large companies possess the resources for ensuring cybersecurity, but this is equally complementing SaaS adoption as the companies can understand their technical security requirements and appreciate the SaaS vendors competencies.

Finally, cloud characteristics was recognized as the fourth factor which affects SaaS ERP adoption for large companies. The essential characteristics – such as mobile access, improved user interfaces, and continuous technical innovations [3, 21] – are indeed desirable features for ERP systems. These might also moderate on the other factors: for example, if cloud characteristics are valued highly, it may help adoption even if the costs of the system would increase. However, from an adoption point-of-view some of these characteristics can also prevent the cloud ERP adoption of large companies. Frequent upgrades cause extensive testing efforts especially for large companies, as they require their own extensions and vast integrations to external systems. SMEs rarely have similar requirements, which is yet another difference to large companies on SaaS ERP adoption. While the promise of continuous new innovations to a SaaS ERP system may initially sound appealing, the reality of the required testing workload may hinder adoption. ERP upgrades in general require rigorous and costly testing efforts [44, 45]. As the research results also indicate that large companies are hesitant to upgrade their current on-premise ERP systems, the frequent upgrades and their required testing efforts can be seen as a disadvantage of SaaS ERP. These results and their properties are summarized in Table 2 below.

Although currently these factors are preventing a full-scale adoption of public cloud SaaS ERP for large companies, this may very well change in the near future. As cloud services evolve, their technical maturity will help to address some important factors, such as guaranteeing business continuity. This study is contributing to the field of information systems research by helping to fill the gap on which factors affect large companies SaaS ERP adoption. It highlights the differing requirements of large companies when compared to SME's, while helping to understand how cloud vendors could be fulfilling their specific needs. We recognize that the research has some limitations, as it is only focused on one SaaS ERP vendor and large companies that are based on a single country, even though their operations are international. Further research could be conducted on evaluating how different cloud vendors are able to answer these requirements, as well

Table 2. Factors affecting SaaS ERP adoption.

Factor	Properties	Main drivers for large companies
Service quality	System availability	System needs to be available during critical business hours, SLA's need to guarantee sufficient availability and compensation for breach
	Support transparency	Trustworthiness of support process, companies require incidents to be handled and communicated visibly
	Personality of support	Familiar experts who the company can contact immediately, instead of an anonymous incident channel
Costs	Implementation effort	Amount of time and money required to install and configure the system
	Operational costs	Required fees and labor hours to operate the system
	Total Cost of Ownership	The total costs for the complete lifecycle of the system, including implementation, operation and decommissioning
Technical limitations	Network latency	Latency challenges between on-prem legacy system integrations or on-site systems, such as automation lines
	Customizing capabilities	Amount of customizing that can be performed in the information system
	Flexibility	How well the predefined, best-practices business processes are fit for the company and how much they can be enhanced
	Information security	Technical information security, required amount of security enhancements, or the perceived security threats with cloud systems
Cloud characteristics	Ease of use	New applications and user interfaces enhancing end user experience
	Ubiquitous access	Access the cloud system widely and easily, e.g. without connecting VPN
	Mobile applications	Specific mobile friendly applications available on handheld devices
	Frequent upgrades	System upgrades providing the latest innovations while also requiring constant testing of e.g. integrations and customer enhancements

as in various companies in different geographical areas to understand the phenomenon more deeply.

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