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Impacts on the organizational adoption of cloud computing: A reconceptualization of influencing factors

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Abstract

The attitude towards cloud computing is influenced by multiple factors acting as drivers and barriers for its adoption. This research paper aims at the reconceptualization and operationalization of widely accepted influencing factors on technology adoption in relation to cloud computing. A literature review on technological innovation characteristics in this context is conducted to identify potential gaps in ongoing research. The review also provides an overview of relevant empirical studies on cloud computing that are based on theories for innovation adoption such as the Diffusion of Innovation (DoI) theory and the Technology Acceptance Model (TAM). Consequently, the focus is set on the examination of the factors “compatibility”, “relative advantage”, “complexity”, “image” and “security & trust”. Furthermore, an operationalization of each factor in the context of cloud computing is provided.

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Keywords: cloud computing; technology acceptance; operationalization; innovation factors; cloud services; DoI; TAM;

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1. Introduction

Cloud computing is a novel way of delivering information technology (IT) services to individuals and organizations [1]. The diffusion and adoption of cloud computing especially among organizations is encouraged through the public availability of cloud services [2, 3] that provide multiple benefits like increased flexibility and agility [4, 5]. Even though cloud computing offers multiple opportunities, the attitude towards cloud computing is influenced by numerous factors acting as drivers and barriers for its adoption [6, 7]. Therefore, the group of opponents of this innovation is also still noteworthy.

Being an important area for IT innovation and business investment [3], the adoption of cloud computing has received increasing attention in both practice and research [8]. Although recent studies have provided information on the current state of the adoption of cloud computing (cf. Table 1), research on drivers and barriers of the broad organizational adoption is still in early stages. Hence, there is still a need to study both the attitude towards adoption and the actual usage of certain cloud application types among organizations of different sizes, industries as well as countries. To serve this purpose a reexamination of influencing factors with a special focus on the context of cloud computing is needed to provide appropriate constructs for operationalization.

The goal of this paper is to provide a reconceptualization and operationalization of important factors for cloud adoption in organizational innovation. The factors must be theoretically based and provide a practical relevance for the context of cloud computing. The remainder of this paper will take this into account and is arranged as follows: Section 2 frames the background and motivates the necessity to derive factors relevant for the intended purpose. Section 3 covers the reconceptualization and the operationalization of the influencing factors previously described. Finally, conclusions and future work are provided in Section 4.

2. Literature review: background and factor exploration in context of cloud computing

To form a rigorous picture it is necessary to consider several factors of innovation simultaneously and to evaluate their relationships [9]. For example Holland and Light identified several critical success factors from a larger list of factors found in relevant research [10]. The innovation factors that have the most consistently significant relationships to innovation adoption are *compatibility*, *relative advantage*, and *complexity* [9]. These three factors originate from Rogers' Diffusion of Innovation (DoI) theory, stating that diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system" [11], whereas an innovation is "an idea, practice or object that is perceived as new by an individual or other unit of adoption" [11]. *Compatibility*, *relative advantage* and *complexity* are perceived attributes of innovations that help to explain the adoption of innovative technologies and therefore are considered to be relevant in the context of this research. In addition to the factors stated by Rogers' DoI, Moore and Benbasat considered the construct *image* as an important factor within their development of an instrument to measure the perceptions of adopting an information technology innovation. Some authors include *image* within the factor *relative advantage* (e.g. Rogers [11]). This has been criticized, as the effect of *image* is rather different from the effect of *relative advantage*. Therefore, *image* should be specified as self-contained factor [9, 12, 13].

To examine the adoption of complex, new and interactive technology it is beneficial to take factors from more than one theoretical model into account to express the multi-faceted nature of such an adoption phenomenon [3]. For this purpose Davis' Technology Acceptance Model (TAM) was included in the examination [14]. Therein Davis investigates two main issues: To find reasons for users to accept or reject information technology and to cover the impact of design features of a system on user acceptance. He investigates causal relations between external stimulus, cognitive response, affective response and behavioral response. The *perceived usefulness* and *perceived ease of use* factors determine the cognitive responses to system design features. However, due to the clear similarity of *perceived usefulness* and *perceived ease of use* to *relative advantage* and *complexity* [12], these two factors are of particular interest in the context of cloud computing and therefore are being discussed within the sections of *relative advantage* and *complexity*. Davis' TAM primarily aims at influences on the behavior of individuals whereas this research focuses on the organizational perspective. However, Benamati and Rajkumar stated that many IT decisions, such as that of outsourcing, are made by single individuals at the executive levels of an organization. Thus the application of TAM, which is designed to elicit responses of an individual, is appropriate to evaluate acceptance of certain organization-wide technology decisions [15]. However, TAM and its modified versions are criticized for failing to address certain issues such as security and trust [16] which therefore have been included in this paper as well.

An examination of the adoption of innovations should focus on both the attitude towards adoption and actual usage as the dependent variables [9]. Davis' TAM also suggests distinguishing between those two variables. In a recent study on Software as a Service (SaaS) adoption, based on the theory of planned behavior [17], Benlian et al. found that the attitude toward the behavior to adopt influences the actual SaaS adoption as well [18].

Based on these considerations, Table 1 presents an overview of existing literature on the adoption of, attitude towards, benefits and barriers of technological innovations. This includes mainly empirical surveys that analyze different factors based on well-established models and frameworks, as well as conceptual papers that aggregate these factors. Armbrust et al. [19] deliver an aggregation of common obstacles and opportunities for cloud computing. Altaf et al. [5], Behrend et al [20], Borgman et al. [21], Compeau et al [22], Gregg et al [24], Karahanna et al. [25], Lawkobkit et al. [26], Sonnenwald et al [27], Li et al. [7], Low et al. [3], Tan et al. [28], Tjikongo et al. [29], Venkatesh et al. [31] and Wu [16] carried out empirical surveys. Dillon et al. [23] and Tornatzky et al [30] focus on the conceptualization of frameworks and Won [32] discusses the terminology advantages, current status and adoption issues. Since this paper focuses on the factors of *compatibility* (CPT), *relative advantage* (RA), *complexity* (CPX), *image* (I) and *security & trust* (S&T) which are widely accepted and verified, the table below uses these categories for comparison.

Table 1. Overview of literature on technological innovation characteristics.

Source	Scope	CPT	RA	CPX	I	S&T
Altaf et al. (2010) [5]	Empirical survey (N=101), Northeastern US businesses having less than 500 employees (SMEs), 6 factors, 3 factors with significant association (cost, functional capability, flexibility)		x	x		
Armbrust et al. (2010) [19]	Aggregation of common obstacles and opportunities for cloud computing.	x			x	x
Behrend et al. (2011) [20]	Empirical survey (N=760) among US college students, TAM model used, factor ease-of-use perception was a much stronger predictor of adoption than the usefulness perception		x	x		
Borgman et al. (2013) [21]	Interviews (N=24), global enterprises (nine from Germany, five from Benelux, two from Italy, Austria and the United States, as well as five each from another country), 8 factors from TOE framework examined, 3 factors confirmed (relative advantage, top management support, competition intensity)	x	x	x		
Compeau et al. (2007) [22]	Employees (N=380) of a community hospital, focusing on their perceptions and use of a comprehensive hospital computer system. Building on studies over the past ten years as well as on additional empirical research, we provide two contributions – a reconceptualization and refinement of the Perceived Characteristics of Innovating (PCI) constructs, as defined by Moore and Benbasat in 1991 and an extended theoretical model of their influence on users' behavior.	x	x	x	x	
Dillon et al. (2010) [23]	Conceptualization of cloud service models, deployment models and aggregation of their issues and challenges	x	x		x	x
Gregg et al. (2008) [24]	Empirical survey on eBay (between 43 and 169 bidders). Perceived image of sellers influences the willingness to transact with the company, and the prices they are willing to pay for the company's goods and services.		x		x	
Karahanna et al. (2006) [25]	Empirical survey (N=278) among users of a customer relationship management system, 7 factors based on technology acceptance model: compatibility with preferred work style, compatibility with existing work practices, compatibility with prior experience, compatibility with values, perceived usefulness, perceived ease of use, usage	x	x	x		

Source	Scope	CPT	RA	CPX	I	S&T
Lawkobkit et al. (2012) [26]	Empirical survey (N=490) among US employees, 5 factors analyzed (post-acceptance model), perceived usefulness and satisfaction influence IS continuance intention, structural service fairness significantly enhances satisfaction		x			
Li et al. (2012) [7]	Empirical survey (N=225) among students in Taiwan, 10 factors based on theory of planned behavior, technology acceptance model, computer learning theories, and social and economic exchange theories have significant impacts.		x	x		x
Low et al. (2011) [3]	Empirical survey (N=111) among firms belonging to the high-tech industry in Taiwan, 8 factors derived from TOE framework were tested, 5 factors showed significant effect (relative advantage, top management support, firm size, competitive pressure, trading partner pressure)	x	x	x		
Park et al. (2013) [8]	Empirical survey (N=188) among unspecified respondents, 4 + 2 factors analyzed (two-factor theory) and relevant for intention to switch (omnipresence and collaboration support as benefits to switch; satisfaction and breadth use of incumbent IT as costs to switch)					x
Sonnenwald et al. (2001) [27]	Empirical survey (N=80) with a pilot test including 3 pairs of study participants. Five attributes of innovations that influence technology adoption based on DoI theory proposed: relative advantage, compatibility, complexity, trialability and observability.	x	x	x		
Stieninger et al. (2014) [6]	Exploratory expert interviews (N=9) in SMEs in Austria, 19 factors identified in total	x	x	x	x	x
Tan et al. (2011) [28]	Initial results of empirical survey (N=34) among US students (MBA course), 3 factors from IS continuance model analyzed (confirmation and perceived usefulness positively affect satisfaction; satisfaction has positive influence on continuance intention)		x			
Tjikongo et al. (2013) [29]	Empirical survey (N=60) among SMEs in Namibia, TAM factors were tested (usefulness contributes to actual usage and ease of use to intentions of future use)		x	x		
Tornatzky et al. (1990) [30]	Conceptualization of Technology-Organization-Environment(TOE)-framework, 9 factors, environment: industry characteristics and market structure, technology support infrastructure, government regulation; organization: formal and informal linking structures, communication processes, size, slack; technology: availability, characteristics	x		x		
Venkatesh et al. (2003) [31]	Empirical longitudinal survey (N=645) among four organizations, 8 existing models were combined, four core determinants of intention and usage (performance expectancy, effort expectancy, social influence, facilitating conditions) and four moderators of key relationships (gender, age, experience voluntariness of use) were tested.		x			
Won (2009) [32]	Discussion of terminology, advantages, current status, adoption issues and market prognosis	x	x			x
Wu (2011) [16]	Empirical survey (N=42) within Taiwanese technology organizations, 8 factors based upon extended TAM analyzed and explorative model built (marketing effort, security and trust as additional constructs)		x	x		x

3. Reconceptualization and operationalization of five influencing factors for cloud computing

As the literature review revealed, there is a lack of research covering all five factors while also providing an operationalization in the context of cloud computing. This section aims at addressing this gap by revisiting these five factors and providing suitable operationalization for cloud computing.

3.1. Compatibility

The *compatibility* factor is derived from Rogers' DoI theory. "*Compatibility* is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters." [11]. According to experts interviewed during a study, cloud computing occasionally runs the risk of conflicting with the established company philosophy [6]. Tornatzky et al. define *compatibility* factor in a more operational way as "congruence with the existing practices of the adopters" [9]. In addition, Premkumar et al. distinguish between technical compatibility and organizational compatibility [33].

This factor was chosen for further investigation because, according to Tornatzky et al., *compatibility* is the most frequently cited one. Armbrust et al. state, that today the biggest challenges concerning this factor are process and data compatibility [19], because, due to lack of standardization, vendor changes can cause additional costs for system migration and integration [32]. Consequently, increased compatibility influences the adoption intention and the actual adoption of cloud computing in a positive way [3, 9, 13, 21].

Following the aforementioned studies, an operationalization of the factor *compatibility* can be done by using a number of items. According to Premkumar, technical and organizational aspects have to be included [33]. Based on existing findings we identified the following items as relevant to the *compatibility* factor in the context of cloud computing:

- **Data exchangeability**: Borgman et al. identified data exchangeability as an important challenge on the technical side [21]. It ensures customers to easily extract their data from a cloud computing provider.
- **Process integrability**: At the organizational level Borgman et al. identified process integrability as the most important item [21].
- **Vendor interoperability**: Since missing standardization can cause lock-in effects that prevent customers from moving from one vendor to another through additional costs for migration and integration [21], vendor interoperability facilitates this by using widely accepted standards.

3.2. Relative advantage

The *relative advantage* factor originates from Rogers' DoI theory. *Relative advantage* is defined as "the degree to which an innovation is perceived as being better than the idea it supersedes" [11]. In the context of information systems, the application of this theory revealed that the *relative advantage* is one of the most important factors for adoption decisions [34]. Cloud computing solutions provide several relative advantages including load relieving of the network infrastructure, reduction of hardware maintenance and infrastructure operation, flexibility, simple administration, collaboration opportunities, potential cost savings, and increased automation [6].

Moore and Benbasat state that there are clear similarities between the constructs of *relative advantage* (Rogers, DoI) and *perceived usefulness* (Davis, TAM) [12]. *Perceived usefulness* has been defined as "the degree to which an individual believes that using a particular system would enhance his or her job performance." [14], and more recently as "the value provided to the individual by the technology" [5].This factor first originated in Davis' TAM [14] and has been used in many studies exploring the adoption of information technology, including those exploring cloud computing (e.g. [2, 20]).

Related to cloud computing and SaaS in education, *perceived usefulness* was found to significantly impact satisfaction [35] and influence beliefs about the future utility of such systems [20]. *Perceived usefulness* of cloud computing has also been explored in large, publically traded enterprises. Opitz et al. learned that *perceived usefulness* was a strong determinant of intention to use cloud computing [2]. Wu discovered that *perceived usefulness* is a key success factor of SaaS adoption within Taiwanese technology organizations [16]. However, some studies have revealed only a marginal impact of *perceived usefulness* of SaaS on intention to adopt [5] and also rejected *perceived usefulness* as a predictor of adoption [29]. Furthermore, investigating the use of systems after its adoption, a recent study explored post-acceptance technology continuance and found that the impact of *perceived usefulness* on continuance of cloud computing was statistically significant and presented one of the highest predictive values [26].

Based on existing literature there is a large group of items that must be examined for the operationalization of the *relative advantage* factor. The discussion above led to the following items to be considered for cloud computing:

- **Usefulness**: The advantage provided by a cloud computing solution compared to a conventional solution can be indicated by the degree to which the accomplishment of tasks is supported by the solution [27].
- **Quality**: Ideally, the implementation of a certain cloud solution leads to the improvement of the quality of results compared to the solution it superseded. Sonnenwald et al. found that the quality of results is an indicator for the *relative advantage* [27].
- **Convenience**: Another important item for the operationalization of the factor *relative advantage* is the convenience provided by the adopted system as stated by Sonnenwald et al. [27].
- **Costs**: Borgman et al. use the indicator costs as an item to operationalize *relative advantage* by illustrating a potential reduction of overall spending on IT. They found that cost reduction leads to a higher *relative advantage* for adopters of cloud computing [21].
- **Speed**: Low et al. state that *relative advantage* can be measured using speed as item representing speed of business communications, efficient coordination among firms, better customer communications, and access to market information mobilization [3].
- **Performance**: Venkatesh et al. use performance expectancy as “the degree to which an individual believes that using the system will help him or her to attain gains in job performance” [31] as an indicator to operationalize *relative advantage*.

3.3. Complexity

The third factor to be investigated is *complexity*. Rogers defines it as “the degree to which an innovation is perceived as relatively difficult to understand and use” [11]. The longer it takes to understand and to implement an innovation, the more likely it is that complexity turns into a barrier for adoption of a new technology. This is why complexity usually negatively affects adoption of technologies [3, 21, 33]. However, a study among SMEs revealed that experts do not consider cloud computing as a very complex technology to implement due to simple administration tools, high usability as well as a high degree of automation [6]. In TAM, Davis describes *complexity* from a positive point of view and uses the term *ease of use*. He defines it as “the degree to which an individual believes that using a particular system would be free of physical and mental effort” [14]. Even though there are general differences between Rogers’ DoI theory and Davis’ TAM (i.e. Rogers focuses on the organizational and Davis on the individual perspective, concerning *complexity* and *ease of use*), they are both discussing the perception of individuals.

According to Sonnenwald et al., *complexity* refers to “the perceived difficulty of learning to use and understand a new system or technology” [27]. They suggest operationalizing *complexity* through usability instruments, *perceived ease of use* and ease of learning a system. According to them proper items are the system’s potential for frustration, flexibility, task adequacy and expectation conformity [27]. To operationalize *complexity* we therefore identified the following items as relevant for cloud computing:

- **Frustration**: Sonnenwald et al. use frustration while using the system to measure *complexity* in the sense of perceived difficulty of using and understanding a system [27].
- **Flexibility:** Furthermore, they use the flexibility of using a system in the sense of rigidness of the provided interaction form to measure *complexity* [27].
- **Task adequacy:** During the evaluation of a system Sonnenwald et al. scrutinized the participants’ experiences concerning this indicator for *complexity* by asking how easy it is to get the system to fulfill important tasks [27].
- **Expectation conformity:** According to Sonnenwald et al., unexpected behavior leads to increased perceived *complexity* of a system [27]. Expectation conformity is a necessity in cloud solutions and therefore this item was chosen as indicator for the factor *complexity*.

3.4. Image

"*Image* is the degree to which use of an innovation is perceived to enhance one's image or status in one's social system." [12]. Research suggests that organizations with a greater online image benefited from a stronger consumer willingness to transact as well as the ability to impose price premiums for e-commerce transactions [24]. As a survey revealed, the factor *image* is also of high importance in the context of cloud computing because it is transferred from the adopted technology to the company [6]. The impact of adopting cloud computing can have serious negative consequences for an organization. Many organizations have witnessed the impacts of outages of cloud service providers and the impact on organizations that leverage third-party cloud services [36]. In some cases cloud service providers may hide data loss incidents to maintain their reputation [37]. Furthermore, the issue of "reputation-fate sharing" [23] may occur if an organization shares cloud resources with a malicious organization. The behavior of one organization may affect the reputation of all users or organizations of the cloud service, even on those that are innocent simply because cloud resources were shared.

For the factor *image* we identified the following items as relevant in the context of cloud computing:

- **Reputation of the cloud service provider**: Gregg et al. stated that the willingness to transact with a certain cloud service provider (CSP) depends on the CSP's image and reputation [24].
- **Reputation of the innovation**: Following Dillon et al., the company's reputation is affected by the specifics of the adopted solution [23]. For this reason the factor *image* can be operationalized by the reputation of the cloud solution.
- **Innovativeness**: According to Gregg et al., the innovativeness of a technological solution influences its adoption rate [24]. This is why the rating of this item indicates the impact of the factor *image*.

3.5. Security & trust

As a literature overview by Gefen et al. shows, there are a multitude of differing approaches for the conceptualization of trust [38]. Subsequently, there are numerous trust objects and measures to operationalize the impact of trust on the adoption of technological innovations [38]. For this scope, the factor is considered as the ability of the involved actors to convey the perception of trustfulness [6]. Buyya describes trust as a critical quality of service (QoS) parameter which, besides others, has to be considered in service requests in the context of cloud computing [39]. Especially regarding public cloud scenarios this factor is crucial [40]. Currently there is still a lack of confidence to cloud computing, probably due to its novelty. To encourage trust Buyya et al. suggest providing personalized service level agreements (SLAs) for customers, communicating constantly with them and encouraging feedback [41]. Furthermore, *perceived security and safety* appear to have a strong influence on trust in this context. Gefen et al. refer to it as elements of the trust building process [38]. An investigation of influencing factors for the acceptance of cloud computing among SMEs in Austria revealed the importance of *perceived security and safety* in the context of the adoption process [6]. This construct highlights the existing attitudinal differences concerning cloud computing among the groups of experts. The supporters of cloud computing state that its adoption contributes to improved security [42], the opponents criticize privacy management and data security [6]. As an empirical study by Park and Ryoo revealed, *perceived security and safety* can act as an enabler and an inhibitor within a switching scenario from conventional IT to cloud services [8]. Following Wu, within this research *perceived security and safety* were applied as an element of trust and thus security and trust were combined to one factor [16].

Based on current literature we identified the following items as appropriate for the operationalization of the *security & trust* factor in the context of cloud computing:

- **Data security**: According to Stieninger and Nedbal, improved data security standards play a crucial role for organizations in the adoption decision process of cloud computing solutions [6].
- **Trustfulness of the cloud service provider**: Wu [16] found that trustfulness of cloud service providers is essential for the adoption of a cloud solution.

- **Contractual agreements**: Contractual agreements define certain service levels that cloud service providers must comply with. These agreements build confidence by defining security and safety standards and thereby lead to higher perceived trust [6, 41].
- **Geographical location**: As exploratory expert interviews conducted by Stieninger and Nedbal revealed, the geographical location where data is stored or processed plays a major role in the selection process of a cloud service provider. Reasons for this are on the one side differences in legal regulations and on the other side the perceived quality and availability of support services [6].

4. Conclusions and future work

Within this paper, the authors provided a discussion of relevant factors influencing the intended and actual usage of cloud services. The focus was on public cloud services in the organizational context. The contribution and main results of this research target both research and practice.

Based on widely accepted theories such as Rogers' DoI theory [11] and Davis' TAM [14] the paper discusses, re-conceptualizes and operationalizes main factors for use in the context of cloud computing. This provides researchers a rigorous basis for model and theory development.

With the operationalization provided herein, the paper provides an essential basis for an empirical evaluation of cloud services and their current state within the adoption process. The results of such an evaluation in turn might contribute to the enhancement of the perception of cloud computing in general and thereby lead to an amended overall perception of cloud computing which again accelerates its diffusion.

Certainly there may be additional factors and accordingly even more aspects which may have not been considered within this paper. Nevertheless, the five factors and their operationalization discussed in this paper cover highly important areas aiming to bridge a gap between current research and practice.

In order to pursue research on the basis as provided above, the next steps to be undertaken are the development of a survey instrument based on an explorative multi-theoretical model containing the discussed factors. This model has to be verified in a quantitative survey.

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