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# Structural equation modeling in cloud computing studies: a systematic literature review

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## Abstract

**Purpose** – This study aims to examine the current state of literature on structural equation modeling (SEM) studies in "cloud computing" domain with respect to study domains of research studies, theories and frameworks they use and SEM models they design.

**Design/methodology/approach** – Systematic literature review (SLR) protocol is followed. In total, 96 cloud computing studies from 2009 to June 2018 that used SEM obtained from four databases are selected, and relevant data are extracted to answer the research questions.

**Findings** – A trend of increasing SEM usage over years in cloud studies is observed, where technology adoption studies are found to be more common than the use studies. Articles appear under four main domains, namely, business, personal use, education and health care. Technology acceptance model (TAM) is found to be the most commonly used theory. Adoption, intention to use and actual usage are the most common selections for dependent variables in SEM models, whereas security and privacy concerns, costs, ease of use, risks and usefulness are the most common selections for causal factors.

**Originality/value** – Previous cloud computing SLR studies did not focus on statistical analysis method used in primary studies. This review will display the current state of SEM studies in cloud domain for all future academics and practical professionals.

**Keywords** Systematic literature review, Technology adoption, Cloud computing, Structural equation modeling, Continuous technology usage

**Paper type** Literature review

## 1. Introduction

### *1.1 Cloud computing*

Cloud computing, which is/was considered both as a technological concept and as a technology in practical use, has been on the rise in the last decade but it is, in its essence, not

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a new technology (Zhang, Cheng and Boutaba, 2010). The main underlying idea of cloud computing, existence of a mainframe and other distant clients connected to the mainframe is an older concept but with the technological developments practical usage of cloud computing has been realized in late 2000s. Cloud services are developed and presented to users by cloud providers for both organizational and personal use cases with numerous different purposes from completing simple daily life tasks (e.g. keeping a calendar, storing e-mails) to meeting large scale commercial needs (e.g. ERP systems for manufacturing facilities, database management for companies).

With the introduction of new functionalities and capabilities of the cloud services, the adoption and usage of cloud by individuals and organizations for practical use cases has increased and varies; and in accordance with that, the scholars have shown further interest in cloud studies, by implementing the existing theoretical knowledge and by proposing new models (Senyo, Addae and Boateng, 2018). Studies focusing on cloud adoption and studies analyzing the continuous usage of cloud services or tools by particular user groups for different purposes appear widely in the literature. Not only there are academic studies on cloud computing but also cloud technologies are used in academia for researches as cloud can offer higher computation power easier than the previous local server alternative (Bottum *et al.*, 2017).

In technology adoption or usage studies, researchers typically design a conceptual model based on the hypotheses they aim to test. The factors and the constructs used in these models can be taken separately from the related literature or can be selected based on an expert opinion. The constructs can also be adopted directly from previous theories and frameworks. Technology acceptance theories can be employed in adoption studies whereas behavioral, cognitive, or business theories can be employed in both adoption and usage studies to design the conceptual research models (Dwivedi *et al.*, 2017). Different statistical techniques are used to validate a proposed model, some of the widely used ones in the academia being regression analysis, structural equation modeling (SEM), and latent class analysis. Building conceptual adoption models based on technology acceptance theories and using statistical analysis methods like regression analysis or SEM is a practice that predates the development of cloud computing and many other technological developments have been studied with this approach such as acceptance of mobile commerce (Wu and Wang, 2005), online shopping (Gefen *et al.*, 2003), or even personal computers (Igbaria *et al.*, 1997). When cloud computing was introduced as a technology in practical use, the technology acceptance researches in this area also began to be conducted, as expected.

This SLR study aims to present a summary of the current literature in cloud computing domain, by limiting the scope on the researches that have employed the SEM as the primary statistical analysis tool. These studies will be referred to as "cloud computing–SEM studies" throughout this paper. To give insight about the theoretical background that these papers are based upon, theories and frameworks employed in at least three different studies in the final article pool of this systematic literature review (SLR) are listed in Table I.

### *1.2 Structural equation modeling*

SEM is a statistical analysis method based on multiple regression analyses, used to quantitatively test a theoretical model hypothesized by the researchers. SEM assumes that the researcher has specified a priori model that will undergo validation testing. SEM tests hypotheses about pairwise relations between variables that are measured directly or the variables that are observed through other several causal factors. In the past, SEM has not only been important for social sciences but also has been becoming a technique of choice for researchers from many other disciplines like information systems and technology (Ringle *et al.*, 2012). SEM is used for both social and economic systems and models because of the

possibility of forming econometric models while taking the notion of unobserved variables from a psychometric perspective into consideration (Fornell and Larcker, 1981).

SEM started to appear in the literature in the 1970s and it gained more interest in the 1980s. The observation and formulation of complex problems in social sciences and the increase in computation power are seen as the main factors of the interest in the usage of SEM over time. However, SEM is not a technique invented in 1970s and its development can be better understood with the previous algorithms and statistical techniques on which SEM is based; mainly regression analysis, path analysis, and confirmatory factor analysis (Westland, 2015).

Regression models mainly focus on prediction of a dependent variable using a set of independent observed variables. What made the regression analyses possible initially was the correlation coefficient formula (Pearson, 1897). Path analysis models are also based on regression analyses and correlation coefficients, and are used to test more complex relations between observed variables (Wright, 1934). The factor analysis as a term was first coined to define a two-factor construct for an intelligence theory in which the correlation coefficient was used to create the factor model to define constructs using summed scores of individual responses to a set of correlated items (Spearman, 1927). The confirmatory factor analysis (CFA) technique as it is used today was fully developed later on (Jöreskog, 1969). Based on its underlying structure, SEM is a combination of path models and CFAs. During 1970s researchers began to realize advantages of SEM models in modeling and understanding constructs with unobserved variables. Additionally, SEM also can be used in hybrid approaches together with other statistical analysis models. In these hybrid models output of SEM can be used as input for the next step. G. W.-H. Tan *et al.* (2014) used SEM and artificial neural networks (ANN) for an adoption study on mobile learning technologies. Raut *et al.* (2018) developed a three-stage hybrid model which included SEM, ANN and interpretive structural modeling (ISM) for their cloud adoption study.

One of the main reasons why SEM gets increasingly more usage in recent researches is that SEM allows using multiple observed variables to define a phenomenon. Unlike other statistical methods (e.g. simple linear regression analysis) which might be limited in the number of related variables they can test, SEM can be used to build and test complex models. Furthermore, as computation power increases and computers get more capable, SEM software packages are becoming easier to use. All these above mentioned factors have resulted in an increase in the usage of SEM, becoming a technique chosen by more and more researchers in the information systems domain over time (Ringle *et al.*, 2012). Davis (1989) investigated the use of SEM particularly in information systems (IS) domain by employing SEM as the statistical tool to analyze the data in his information systems study, which was followed by other similar and replication studies such as Adams *et al.* (1992), Segars and

**Table I.**
Theories and models found in at least three studies

| Theory/Model name | Abbreviation | Reference |
|---|---|---|
| Technology Acceptance Model | TAM | (Davis, 1989) |
| Technology–organization–environment | TOE | (Tornatzky *et al.*, 1990) |
| Diffusion of innovation theory | DOI | (Rogers, 2010) (first published in 1962) |
| Unified theory of acceptance and use of technology | UTAUT | (Venkatesh *et al.*, 2003) |
| Theory of reasoned action | TRA | (Ajzen and Fishbein, 1973) |
| Theory of planned behavior | TPB | (Ajzen, 1991) |
| Dual factor theory | 2FT | (Herzberg, 2017) (first published in 1959) |
| Transaction cost theory | TCT | – |
| Social cognitive theory | SCT | (Bandura, 1986) |
| Status Quo Bias | SQB | – |

Grover (1993) and Chin and Todd (1995). Although this literature review particularly focuses on cloud adoption and usage studies with SEM, SEM has been used in many IS studies in the last decades as a statistical analysis technique by researches that have a model or a set of hypotheses to be tested based on sampled and collected data (Urbach and Ahlemann, 2010). It is seen in these researches that the most common reasons for choosing SEM are small sample sizes, non-normality, exploratory research objective/predictive purposes, analyzing formative and reflective constructs, number of interaction terms and mediated models (Kante *et al.* (2018). Having the opportunity to work with relatively smaller sample sizes and non-normal cases are the strong advantages of the technique.

*1.3 Motivation*

There are numerous studies in the literature that analyze the adoption and usage of cloud services both in personal and business cases, with the aim to understand which user groups use what kinds of cloud services and tools for what purposes. However, only a number of them are exploiting SEM as the statistical analysis tool. The main motivation of conducting this SLR is to review these studies, therefore the current state of SEM studies in the cloud computing domain, to summarize what has been done in that area and potentially to discover gaps in the literature regarding the use of SEM in cloud computing studies. In detail, this study aims to put forward the current usage of SEM in cloud computing studies, how commonly SEM is used in cloud adoption and cloud usage studies, what are the theoretical models, constructs and elements of the conceptual models used with SEM and whether SEM gives meaningful results in cloud adoption and usage studies. With the final article pool being examined and the relevant data extracted, this study reveals the specific study domains in which cloud computing – SEM studies have been conducted and the populations that are used as sample sources in the studies. A further motivation to conduct this literature review is that even though there are previous literature reviews and secondary studies on cloud adoption research, none of these previous review studies specifically has focused on SEM usage. The current study, to best of our knowledge, is the first SLR of SEM usage in cloud computing studies, with a supporting purpose to present a compilation of current literature for researchers planning to employ SEM as a statistical analysis method in future studies in the cloud computing domain.

Real life systems consist of numerous components and they are interacted by different groups of people. The cloud computing ecosystem in which this SLR study is interested can be considered as a large system of technologies, research studies and most importantly people. One aspect of this system is the technology developers and service providers. On the other end of the spectrum are users, either large organizational bodies or individuals. What links these two parties is the underlying cloud technology. Developing and extending this technology is affected by the researches and the analyses, both directly and indirectly.

While this study specifically focuses on the cloud adoption and usage studies conducted in the last decade, it also uses a systems thinking approach to analyze the implications of these studies in a larger scale. Systems thinking approach is the concept of taking a step back and observing the system in its entirety to notice the large patterns made up by the components of the system. It aims to help researchers and analysts to not ignore the rest of the system while focusing closely on its components (Senge, 1991).

Technology adoption studies are not theoretical works isolated from real life. On the contrary, they are social studies in their essence as they directly analyze people and their behavior intentions and the results of these studies should be used for future practices in the industry. The process for a technology adoption or use study follows the path of social facts, beliefs and observations to data; and data to information and knowledge; and from

knowledge to future social beliefs. It is only natural that the information gained from the data collected based on social facts will be valuable for the future of the social systems in a cyclic manner (Johannessen *et al.*, 2002). When a technology adoption study using SEM to confirm the conceptual model based on collected data is integrated into this cycle, this system as a whole can be summarized as seen in Figure 1. It also shows the following sections of this article where findings are discussed relevant to the actions and interactions in the system.

Figure 1 only shows the activities and different steps of this system. There are also actors with different roles in this system. Technology providers and users both shape up the social facts to be observed. Technology providers can have sub-categories such as the developer, designer, broker, etc. whereas technology user can be split into several categories such as individual user, manager, contractor, etc. Researchers are other actors in the system, observing the social fact, interacting with users and providers to analyze their beliefs and presenting results of the study that will in turn affect the social facts again.

This SLR study aims to investigate the current state of literature by focusing on the completed studies and present results and conclusions that will be useful to the whole of the system and many different parties in it.

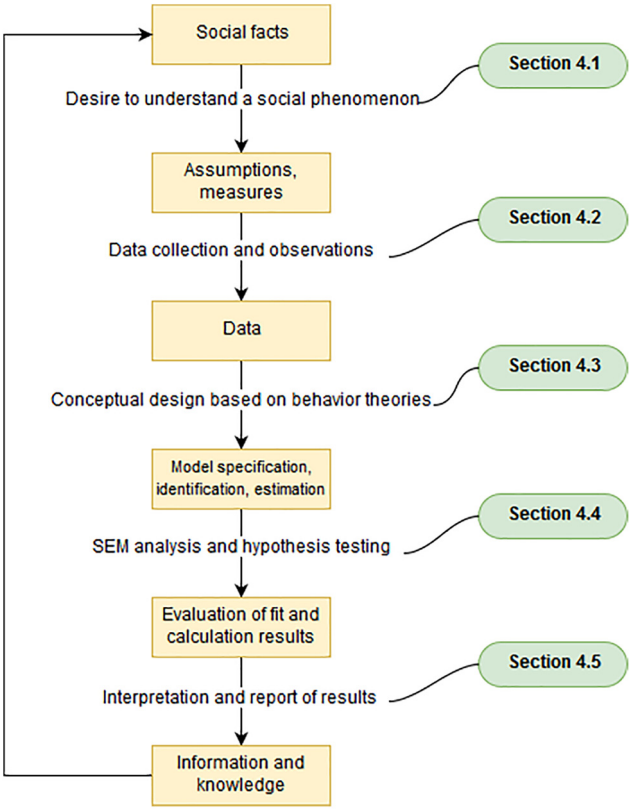


**Figure 1.**
Technology adoption and usage system

## 2. Methodology

### *2.1 Overview*

Main goals of the literature review, the questions that are used to reach these goals, and the metrics that will be used to answer the questions are defined carefully in the preparation step. The most prominent online academic databases are examined to collect relevant studies to obtain the final article pool. Review data according to the metrics are extracted from the selected studies. General guidelines suggested by Budgen and Brereton (2006) are also followed to complete this review study. In the rest of this section, each step of the literature review is explained in detail.

### *2.2 Goal, research questions and metrics*

Two main goals are defined before conducting this SLR. First, we try to identify the current state of literature of SEM studies in the cloud computing domain. Second, we try to identify and classify the employed theories, components of SEM models, characteristics of cloud services, and future directions in SEM studies in the cloud computing domain. Both of these goals are approached from a cloud computing researcher point of view. We focus on demographics and the overall state of the pool of articles that are found relevant and selected in the study to achieve our first goal. On the other hand, our second goal is concerned with the primary studies and the way they are structured and conducted separately. The structure of research goals and questions in the study are defined by using Goal-Question-Metric method (Basili, 1992; Van Solingen *et al.*, 2002). GQM method is employed in previous SLR studies (Garousi and Zhi, 2013; Garousi *et al.*, 2017) to define research questions in preparation step before data extraction. According to this method, main goals of this study are constructed using a Purpose-Issue-Object-Viewpoint structure as given in Table II.

To understand the cloud adoption and usage system in its entirety, the interacting components that make up the system should be analyzed separately and together. To that end, based on the two research goals, research questions (RQs) are defined. The following RQs are raised under each research goal to understand different aspects of the literature:

*Goal 1*: To identify the current state of literature of SEM studies in the cloud computing domain from a cloud computing researcher's point of view:

*RQ1.1*: Who are the authors with the highest number of articles?

*RQ1.2*: Which countries have produced the most articles?

*RQ1.3*: What is the annual article count?

*RQ1.4*: What is the annual article count by venue and/or venue type? What are the publish venues with the highest article count?

| Goal No | 1 | 2 |
|---|---|---|
| Purpose | To identify | To identify and classify |
| Issue | the current state of literature | the employed theories, components of SEM models, study domains, and future directions |
| Object | of SEM studies in the cloud computing domain | in SEM studies in the cloud computing domain |
| Viewpoint | from a cloud computing researcher's point of view | from a cloud computing researcher's point of view |

**Table II.**
Main goals of this review study

*RQ1.5*: What is the citation count by publish venue? (e.g., a conference proceeding, a journal, etc.)

*RQ1.6*: What are the most influential articles in terms of citation count?

*RQ1.7*: Who are the most influential authors in terms of citation count?

*Goal 2*: To identify and classify the employed theories, components of SEM models, study domains, and future directions in SEM studies in the cloud computing domain from a cloud computing researcher's point of view.

*RQ2.1*: What is the purpose of using SEM? (e.g. a cloud adoption study or a cloud usage study)

*RQ2.2*: What are the main domains and cloud services the studies focus on?

*RQ2.3*: What is the target population from which the sample is taken in the study? (e.g. university students, software developers, top level managers, etc.)

*RQ2.4*: What is the sample size of the study?

*RQ2.5*: In which country(ies) did the authors conduct the questionnaire/survey to collect data?

*RQ2.6*: Which theory(ies) is the SEM model in the study based on?

*RQ2.7*: What are the most commonly used constructs/factors in conceptual models (SEM model) of studies?

*RQ2.8*: What limitations are reported? What future research directions are suggested?

The first set of RQs to meet Goal 1 of this research focuses on the demographics of the current literature to get an overview of the cloud adoption system while the second set of RQs are concerned with the actions and interactions of individual components within the system. The related actions in the system, the corresponding RQs, and the following sections in this article that explain the results of the analyses are given in Table III.

To extract correct and relevant data from articles to answer the aforementioned RQs, the metrics in Table IV are defined:

### *2.3 Article selection*

Four online databases were selected to search for previous studies; namely (1) Science Direct, (2) Springer, (3) ACM, and (4) Scopus. The search keywords were defined with the aim of covering all possible research areas with regards to *cloud computing* and *SEM*

**Table III.** Research design with systems thinking

| Action in the system | Research Questions | Article Sections |
|---|---|---|
| Desire to understand a social phenomenon | *RQ2.1, RQ2.2* | Section 4.1 |
| Data collection and observations | *RQ2.3, RQ2.4, RQ2.5* | Section 4.2 |
| Conceptual design based on behavior theories | *RQ2.6* | Section 4.3 |
| SEM analysis and hypothesis testing | *RQ2.7* | Section 4.4 |
| Interpretation and report of results | *RQ2.8* | Section 4.5 |

*analyses* at the same time. The following string of keywords was used in the database searches:

*("cloud computing" OR "saas" OR "paas" OR "iaas" OR "public cloud" OR "private cloud" OR "hybrid cloud") AND "structural equation*

Using this search string on four selected databases for everything up to June 2018 with no defined starting date, an initial pool of 612 results was obtained. StArt (State of the Art through Systematic Review) software tool was used to monitor, categorize, and evaluate the findings (Hernandes *et al.*, 2012). Initial pool of 612 results was imported into StArt for the next steps of SLR. 22 of the 612 initial results were found to be duplicates by the tool and the manual screening of article titles, which reduced the result pool to 590 articles for application of inclusion/exclusion criteria.

### *2.4 Application of inclusion/exclusion criteria*

For the initial screening of results, the following inclusion criteria were considered:

- Study is about cloud computing.
- Study uses SEM to analyze results.
- Study is a review/SLR/secondary study in this area.

Similarly, the initial exclusion criteria are:

- Study is not about cloud computing.
- Study does not use SEM to analyze results.
- Result is not a journal article or a conference proceeding.
- Article is not in English.
- Full text is not available online.

Having applied the aforementioned inclusion and exclusion criteria, 481 results were removed. The remaining 109 articles were found to be eligible for full-text screening at the next stage of the literature review process.

### *2.5 Final pool of articles*

From the pool of 109 articles, 13 were further removed following the full-text examination due to the same set of exclusion criteria used in the previous step of this study. 96 articles (92 of them being primary studies while other four being secondary review articles) were included in the final pool for data extraction. Full list of articles in the final pool of this SLR is given in Table V with the purpose of assigning IDs to be used in the rest of this study. The steps followed in this SLR are graphically summarized in Figure 2.

| | | | |
|---|---|---|---|
| *RQ1.1* | Article count per author | *RQ2.1* | Focus of cloud study |
| *RQ1.2* | Article count per country of author | *RQ2.2* | Study domain and type of cloud service |
| *RQ1.3* | Article count per year | *RQ2.3* | Questionnaire participants |
| *RQ1.4* | Article count per venue per year | *RQ2.4* | Questionnaire sample size |
| *RQ1.5* | Citation count of articles per venue | *RQ2.5* | Country(s) of questionnaire sample |
| *RQ1.6* | Average annual citation count of article | *RQ2.6* | Theory(s) |
| *RQ1.7* | Citation count of articles per author | *RQ2.7* | SEM model constructs |
| | | *RQ2.8* | Limitations and future directions |

**Table IV.** Metrics used to answer research questions in this review study

| ID | Reference | Title |
|---|---|---|
| S01 | (Akar and Mardiyan, 2016) | Analyzing Factors Affecting the Adoption of Cloud Computing: A Case of Turkey |
| S02 | (Al-Ma'aitah, 2017) | The drivers or ERP cloud computing from an institutional perspective |
| S03 | (Al-Ruithe and Benkhelifa, 2018) | Determining the enabling factors for implementing cloud data governance in the Saudi public sector by structural equation modelling |
| S04 | (Alkhalil *et al.*, 2017) | An exploration of the determinants for decision to migrate existing resources to cloud computing using an integrated TOE-DOI model |
| S05 | (Alkhater *et al.*, 2018) | An empirical study of factors influencing cloud adoption among private sector organisations |
| S06 | (Alotaibi, 2014) | Exploring users' attitudes and intentions toward the adoption of cloud computing in Saudi Arabia: an empirical investigation |
| S07 | (Amron *et al.*, 2017) | A Review on Cloud Computing Acceptance Factors |
| S08 | (Arpaci, 2016) | Understanding and predicting students' intention to use mobile cloud storage services |
| S09 | (Arpaci, 2017) | Antecedents and consequences of cloud computing adoption in education to achieve knowledge management |
| S10 | (Arpaci *et al.*, 2015) | Effects of security and privacy concerns on educational use of cloud services |
| S11 | (Asadi *et al.*, 2017) | Customers perspectives on adoption of cloud computing in banking sector |
| S12 | (Benlian, 2009) | A transaction cost theoretical analysis of software-as-a-service (SAAS)-based sourcing in SMBs and enterprises |
| S13 | (Benlian and Hess, 2011) | Opportunities and risks of software-as-a-service: Findings from a survey of IT executives |
| S14 | (Benlian *et al.*, 2009) | Drivers of SaaS-adoption–an empirical study of different application types |
| S15 | (Bhatiasevi and Naglis, 2016) | Investigating the structural relationship for the determinants of cloud computing adoption in education |
| S16 | (Bhattacherjee and Park, 2014) | Why end-users move to the cloud: a migration-theoretic analysis |
| S17 | (Bruque Cámara *et al.*, 2015) | Cloud computing, Web 2.0, and operational performance: the mediating role of supply chain integration |
| S18 | (Bruque-Cámara *et al.*, 2016) | Supply chain integration through community cloud: effects on operational performance |
| S19 | (Burda and Teuteberg, 2014) | The role of trust and risk perceptions in cloud archiving – results from an empirical study |
| S20 | (Cao *et al.*, 2017) | Establishing the use of cloud computing in supply chain management |
| S21 | (Chen *et al.*, 2018) | Antecedents and optimal industrial customers on cloud services adoption |
| S22 | (Chen *et al.*, 2018) | A comparison of competing models for understanding industrial organization's acceptance of cloud services |
| S23 | (Chiregi and Navimipour, 2017) | Cloud computing and trust evaluation: A systematic literature review of the state-of-the-art mechanisms |
| S24 | (Cho and Chan, 2015) | An integrative framework of comparing SaaS adoption for core and non-core business operations: an empirical study on Hong Kong industries |

**Table V.**
Selected articles in the SLR study

(*continued*)

| ID | Reference | Title |
|---|---|---|
| S25 | (de Paula and de Carneiro, 2016) | A systematic literature review on cloud computing adoption and migration |
| S26 | (Du *et al.*, 2013) | User acceptance of software as a service: Evidence from customers of China's leading e-commerce company, Alibaba |
| S27 | (El-Gazzar, 2014) | A literature review on cloud computing adoption issues in enterprises |
| S28 | (Ermakova *et al.*, 2014) | Acceptance of health clouds-a privacy calculus perspective |
| S29 | (Gangwar, 2017) | Cloud computing usage and its effect on organizational performance |
| S30 | (Gangwar and Date, 2016) | Critical factors of cloud computing adoption in organizations: an empirical study |
| S31 | (Gangwar *et al.*, 2015) | Understanding determinants of cloud computing adoption using an integrated TAM-TOE model |
| S32 | (Gangwar *et al.*, 2016) | Understanding cloud computing adoption: A model comparison approach |
| S33 | (Gottschalk and Kirn, 2013) | Cloud computing as a tool for enhancing ecological goals? |
| S34 | (P. Gupta *et al.*, 2013) | The usage and adoption of cloud computing by small and medium businesses |
| S35 | (S. Gupta and Misra, 2016a) | Compliance, network, security and the people related factors in cloud ERP implementation |
| S36 | (S. Gupta and Misra, 2016b) | Moderating effect of compliance, network, and security on the critical success factors in the implementation of cloud ERP |
| S37 | (Haile and Altmann, 2015) | Risk-benefit-mediated impact of determinants on the adoption of cloud Federation |
| S38 | (Hao *et al.*, 2016) | The research of user satisfaction model in hybrid cloud environment |
| S39 | (Hassan, 2017) | Organisational factors affecting cloud computing adoption in small and medium enterprises (SMEs) in service sector |
| S40 | (Hew and Kadir, 2016) | Predicting the acceptance of cloud-based virtual learning environment: the roles of self-determination and channel expansion theory |
| S41 | (Ho and Ocasio Velázquez, 2015) | Do you trust the cloud? modeling cloud technology adoption in organizations |
| S42 | (Ho *et al.*, 2017) | Trust or consequences? Causal effects of perceived risk and subjective norms on cloud technology adoption |
| S43 | (Hsieh, 2015) | Health-care professionals' use of health clouds: Integrating technology acceptance and status quo bias perspectives |
| S44 | (Hsieh, 2016) | An empirical investigation of patients' acceptance and resistance toward the health cloud: The dual factor perspective |
| S45 | (Hsieh and Lin, 2018) | Explaining resistance to system usage in the PharmaCloud: A view of the dual-factor model |
| S46 | (Hsu and Lin, 2016) | Factors affecting the adoption of cloud services in enterprises |
| S47 | (Huang, 2016) | The factors that predispose students to continuously use cloud services: Social and technological perspectives |
| S48 | (Isaias *et al.*, 2015) | Outlining the issues of cloud computing and sustainability opportunities and Risks in European organizations: A SEM Study |
| S49 | (Jede and Teuteberg, 2016) | Understanding socio-technical impacts arising from software-as-a-service usage in companies |

(*continued*)

**Table V.**

| ID | Reference | Title |
|---|---|---|
| S50 | (Lai and Wang, 2015) | Switching attitudes of Taiwanese middle-aged and elderly patients toward cloud health-care services: An exploratory study |
| S51 | (Lawkobkit and Larpsiri, 2016) | Two-dimensional fairness on service recovery satisfaction in cloud computing |
| S52 | (Lee *et al.*, 2016) | Integrating TRA and TOE Frameworks for Cloud ERP Switching Intention by Taiwanese Company |
| S53 | (Li *et al.*, 2016) | Research on the Service Innovation Path for Information Platform in the Cloud Computing Environment |
| S54 | (Lin *et al.*, 2016) | Tourism guide cloud service quality: What actually delights customers? |
| S55 | (Loukis *et al.*, 2017) | An empirical investigation of the effects of firm characteristics on the propensity to adopt cloud computing |
| S56 | (Lübbecke *et al.*, 2016) | Drivers and Inhibitors for the Adoption of Public Cloud Services in Germany |
| S57 | (Maqueira-Marín *et al.*, 2017) | Environment determinants in business adoption of Cloud Computing |
| S58 | (Martins *et al.*, 2016) | An empirical analysis to assess the determinants of SaaS diffusion in firms |
| S59 | (Militaru *et al.*, 2016) | Examining Cloud Computing Adoption Intention in Higher Education: Exploratory Study |
| S60 | (Moqbel *et al.*, 2014) | A study of personal cloud computing: compatibility, social influence, and moderating role of perceived familiarity |
| S61 | (Nguyen *et al.*, 2014) | Acceptance and use of information system: E-learning based on cloud computing in Vietnam |
| S62 | (Oliveira *et al.*, 2014) | Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors |
| S63 | (Ooi *et al.*, 2018) | Cloud computing in manufacturing: The next industrial revolution in Malaysia? |
| S64 | (Padilla *et al.*, 2017) | Impact of service value on satisfaction and repurchase intentions in business-to-business cloud computing |
| S65 | (E. Park and Kim, 2014) | An integrated adoption model of mobile cloud services: exploration of key determinants and extension of technology acceptance model |
| S66 | (S.-T. Park and Oh, 2017) | An empirical study on the influential factors affecting continuous usage of mobile cloud service |
| S67 | (Pathan *et al.*, 2017) | Innovation-diffusion determinants of cloud-computing adoption by Pakistani SMEs |
| S68 | (Phaphoom *et al.*, 2015) | A survey study on major technical barriers affecting the decision to adopt cloud services |
| S69 | (Priyadarshinee *et al.*, 2017) | Understanding and predicting the determinants of cloud computing adoption: A two staged hybrid SEM-Neural networks approach |
| S70 | (Qin *et al.*, 2016) | Evaluating the usage of cloud-based collaboration services through teamwork |
| S71 | (Rahi *et al.*, 2017) | Identifying the moderating effect of trust on the adoption of cloud-based services |
| S72 | (Ratnam *et al.*, 2014) | A structural equation modeling approach for the adoption of cloud computing to enhance the Malaysian health-care sector |

**Table V.** (*continued*)

| ID | Reference | Title |
|---|---|---|
| S73 | (Ratten, 2015) | Social Cognitive Theory and the Technology Acceptance Model in the Cloud Computing Context: The Role of Social Networks, Privacy Concerns and Behavioural Advertising |
| S74 | (Ratten, 2016a) | Continuance use intention of cloud computing: Innovativeness and creativity perspectives |
| S75 | (Ratten, 2016b) | Service innovations in cloud computing: a study of top management leadership, absorptive capacity, government support, and learning orientation |
| S76 | (Raut *et al.*, 2018) | Analyzing the factors influencing cloud computing adoption using three stage hybrid SEM-ANN-ISM (SEANIS) approach |
| S77 | (Sabi *et al.*, 2016) | Conceptualizing a model for adoption of cloud computing in education |
| S78 | (Sabi *et al.*, 2017) | A cross-country model of contextual factors impacting cloud computing adoption at universities in sub-Saharan Africa |
| S79 | (Sabi *et al.*, 2018) | Staff perception towards cloud computing adoption at universities in a developing country |
| S80 | (Schniederjans and Hales, 2016) | Cloud computing and its impact on economic and environmental performance: A transaction cost economics perspective |
| S81 | (Senarathna *et al.*, 2016) | Security and privacy concerns for australian SMEs cloud adoption: empirical study of metropolitan vs regional SMEs |
| S82 | (Senk, 2013) | Adoption of security as a service |
| S83 | (Shana and Abulibdeh, 2017) | Cloud Computing Issues for Higher Education: Theory of Acceptance Model |
| S84 | (Shiau and Chau, 2016) | Understanding behavioral intention to use a cloud computing classroom: A multiple model comparison approach |
| S85 | (Shin, 2013) | User centric cloud service model in public sectors: Policy implications of cloud services |
| S86 | (Shin, 2015) | Beyond user experience of cloud service: Implication for value sensitive approach |
| S87 | (Stieninger *et al.*, 2018) | Factors influencing the organizational adoption of cloud computing: a survey among cloud workers |
| S88 | (Subramanian and Abdulrahman, 2017) | Logistics and cloud computing service providers' cooperation: a resilience perspective |
| S89 | (X. Tan and Kim, 2015) | User acceptance of SaaS-based collaboration tools: a case of Google Docs |
| S90 | (Tashkandi and Al-Jabri, 2015) | Cloud computing adoption by higher education institutions in Saudi Arabia: an exploratory study |
| S91 | (Trenz *et al.*, 2017) | Uncertainty in cloud service relationships: Uncovering the differential effect of three social influence processes on potential and current users |
| S92 | (Trenz *et al.*, 2018) | How to Succeed with Cloud Services? A Dedication-Constraint Model of Cloud Success |
| S93 | (Wang and Wong, 2018) | Bridging Knowledge Divides Utilizing Cloud Computing Learning Resources in Underfunded Schools: Investigating the Determinants |
| S94 | (W.-W. Wu, 2011) | Developing an explorative model for SaaS adoption |
| S95 | (Xu *et al.*, 2017) | Understanding Chinese users' switching behaviour of cloud storage services |
| S96 | (Yadegaridehkordi *et al.*, 2018) | Predicting the adoption of cloud-based technology using fuzzy analytic hierarchy process and structural equation modelling approaches |

**Table V.**

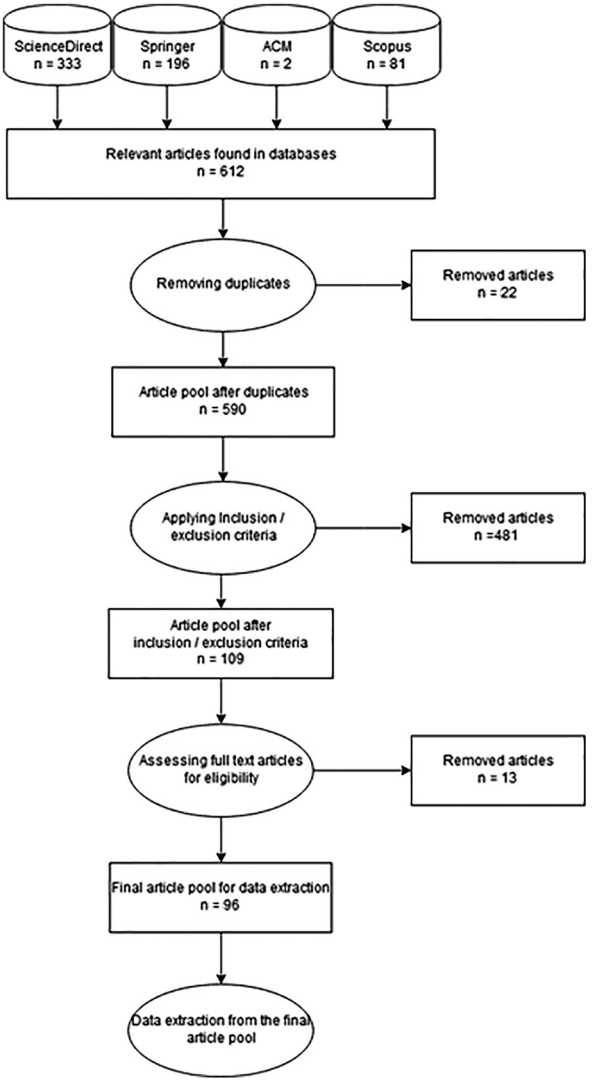


**Figure 2.**
Steps of the SLR

## 3. Articles classification

The first set of RQs related to the first goal of this SLR aim to understand the current state of cloud computing research that uses SEM (cloud computing–SEM studies). They can be answered by taking the entire article pool of 96 results into consideration. Demographics such as the author countries, the publish venues, and the annual research count are given in this section. In section 3.1; *RQ1.1* and *RQ1.2* are answered. In section 3.2; *RQ1.3, RQ1.4, RQ1.5, RQ1.6* and *RQ1.7* are answered.

*3.1 Authors, affiliations, and countries*

There are 201 unique authors that contributed to the 96 cloud computing–SEM studies in the final pool which means that there are approximately two authors on average per study in the area. Most observed author numbers per article are two and three as 32 of 96 articles in the final pool are written by two authors and 28 articles by three authors. The distribution of articles with different author numbers is given in Figure 3. To the best of our knowledge all researchers who contributed to an article examined in this literature review are from academia and there is an absence of researchers from industry in cloud computing SEM studies. It was observed that there is no single author or a single certain research group that carry the most of the research done in this area alone. The author with the highest number of articles is found to be Hemlata Gangwar (National Institute of Industrial Engineering, India) with four articles while there are 11 other researchers who have contributed to three studies each, and also 22 others who contributed to two studies each.

It is observed that in the literature there are studies that have been conducted by authors with affiliations all from the same country as well as studies by collaborating authors with affiliations from different countries. USA has the highest number of cloud computing SEM studies with 13 articles that have contributions from authors affiliated with USA universities, followed by Taiwan with 12, and Germany with 11 author contributions.

Looking at distribution of study domains that studies from different countries focus on, it can be seen that for most countries there is an evenly distribution of SEM cloud studies in different domains (business, education, health care, personal use). From the countries in which more than five cloud computing – SEM studies have been published, India and the UK are the only cases where entirety of the research focus is found to be on a single study domain. Nine studies by authors with affiliations in India and five studies by authors with affiliations in the UK are all on business-oriented cloud models. The distribution of studies from different countries on different study domains can be seen in Figure 4(a).

*3.2 Year of studies, article type, publish venues and citation count*

Cloud computing as an emerging technology started to become of interest for researchers in both academia and industry after 2008 even though it was not a particularly "new technology" at that time (Zhang *et al.*, 2010). The fact that earliest articles in the result pool

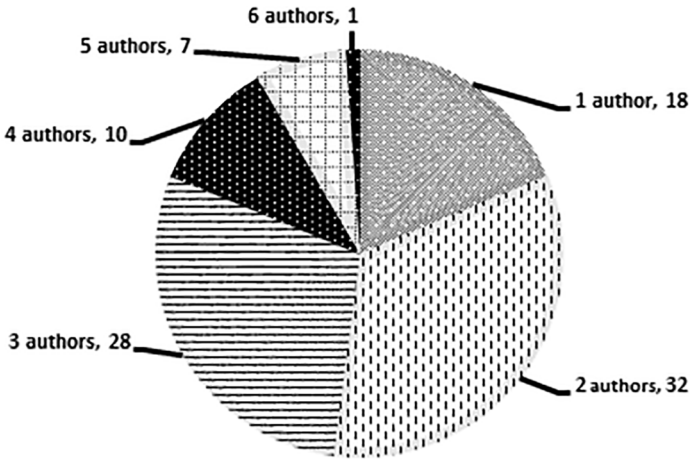


**Figure 3.**
Author numbers per article

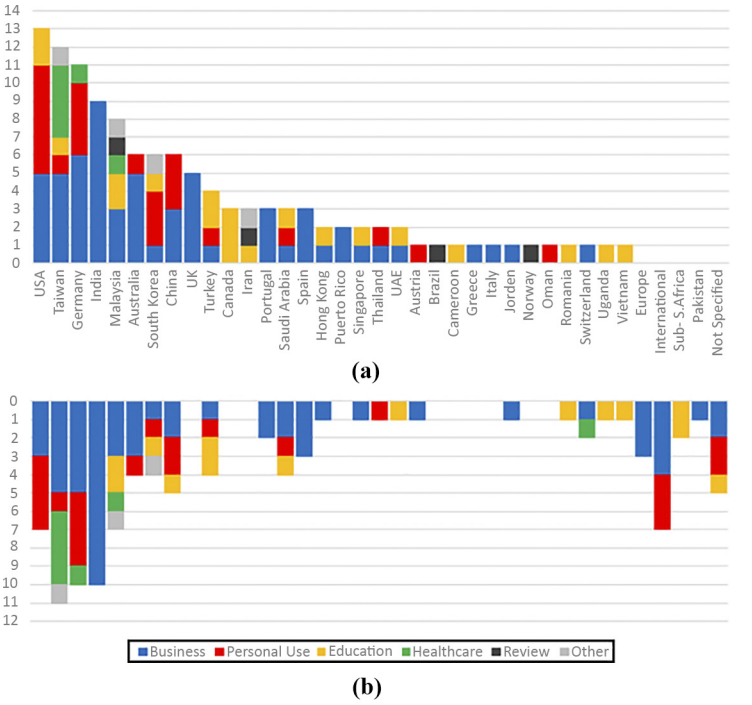


**Figure 4.**
(a) Article count per author affiliation country and (b) article count per survey country

are from 2009 shows that findings in this literature review indeed fall in the same time range. As early as 2009, when cloud computing was still not accepted as a technology that individuals use for daily tasks, there were two studies focusing on potential cloud adoption decision and factors that affect this decision. Over years, more studies using different technology acceptance theories and different conceptual models were conducted. In addition to the cloud acceptance studies, researchers started working on SEM studies on continuous cloud usage. Annual article counts of cloud studies employing SEM from 2009 to first half of 2018 are given in Figure 5.

92 of the articles in the final pool in this review are primary studies whereas there are four secondary studies or literature reviews that focus on different aspects of cloud computing adoption. Primary studies are mainly published in journals (79) while the remaining 13 primary studies are conference proceeding articles. Secondary studies are split between two types evenly with two of them being published as journal articles and the other two as conference proceedings.

Elsevier is found to be the publish venue/publisher that has published the majority of cloud computing–SEM studies with 36 articles, followed by Springer with 26 articles. Article type count, study domains and the purposes of the articles for each venue/publisher can be seen in Figure 6.

Most influential articles when solely considering the total number of citations (based on Google Scholar) are found to be older ones (older with respect to publication year) with S13 at the top, having been referenced/cited 411 times. Most influential article with an alternative index, that is average annual citation count, is found as S62 with a citation count

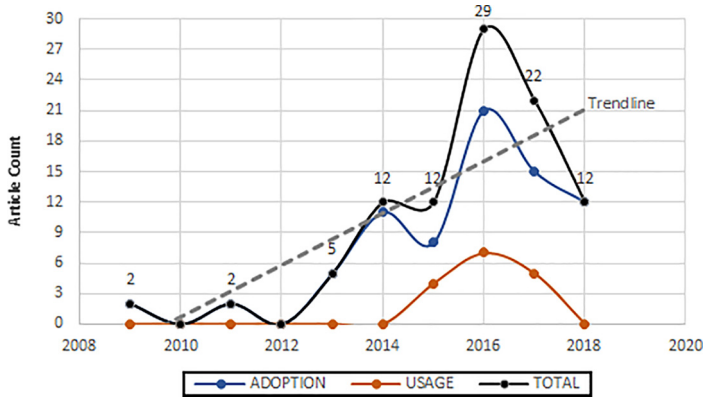


**Figure 5.**
Annual article count

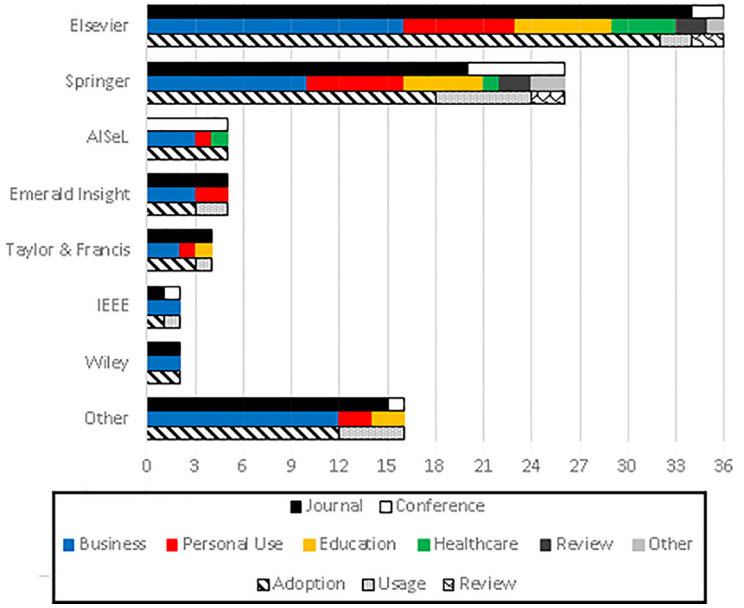


**Figure 6.**
Annual article count per publish venue, study domain and purpose

of 397 total and 79.40 average annual. Top twenty-five influential articles in terms of average annual citation count are given in Table VI.

The most influential author in terms of citation count is found to be Alexander Benlian (Technische Universität Darmstadt, Germany) who contributed to three of the four earliest cloud computing–SEM studies (S12, S13, S14) with a total of 758 citations on Google Scholar. He is followed by Thomas Hess (University of Munich, Germany) with 703 citations of two articles (S13, S14) and Thiago Oliveira (Universidade Nova de Lisboa, Portugal) with 421 citations of two articles (S58, S62).

| ID | Publish year | Total citation count | Average annual citation count |
|---|---|---|---|
| S62 | 2014 | 397 | 79.40 |
| S34 | 2013 | 406 | 67.67 |
| S13 | 2011 | 411 | 51.38 |
| S31 | 2015 | 197 | 49.25 |
| S65 | 2014 | 148 | 29.60 |
| S14 | 2009 | 292 | 29.20 |
| S84 | 2016 | 71 | 23.67 |
| S16 | 2014 | 117 | 23.40 |
| S94 | 2011 | 180 | 22.50 |
| S77 | 2016 | 67 | 22.33 |
| S08 | 2016 | 57 | 19.00 |
| S85 | 2013 | 103 | 17.17 |
| S09 | 2017 | 32 | 16.00 |
| S10 | 2014 | 60 | 12.00 |
| S63 | 2018 | 12 | 12.00 |
| S68 | 2015 | 47 | 11.75 |
| S90 | 2015 | 44 | 11.00 |
| S19 | 2014 | 51 | 10.20 |
| S40 | 2016 | 30 | 10.00 |
| S27 | 2014 | 47 | 9.40 |
| S86 | 2015 | 36 | 9.00 |
| S80 | 2016 | 24 | 8.00 |
| S58 | 2016 | 24 | 8.00 |
| S05 | 2018 | 8 | 8.00 |
| S26 | 2013 | 44 | 7.33 |

**Table VI.**
Most influential articles in terms of average annual citation

## 4. Review of cloud computing – structural equation modeling studies

SLR studies with a focus on cloud computing have been conducted in the past. Examples of the review studies that were interested in other aspects of cloud computing usage can be found, such as the study of Jula *et al.* (2014) which reviewed cloud computing service composition or the study of Latif *et al.* (2014) which was a cloud computing risk assessment review. SLRs that are specifically about cloud computing adoption and/or usage studies are also searched and included in the main article pool of this study. During the database search of this SLR, four previous secondary studies on cloud computing adoption are found in the existing literature. However, none of these four review studies specifically focuses on SEM studies in cloud computing area, which means their scope is different from the scope of this current study. These review studies have covered primary studies included as well as studies excluded here as they do not have a specific limitation regarding the statistical analysis method and approach used. To our knowledge the current study is the first SLR of SEM usage in cloud computing studies.

The first review study on the subject (S27) was published in 2014, reviewing 51 articles published between 2009 and 2014 that were on cloud computing adoption models and theories. The second SLR on cloud adoption studies (S25) was published in 2016. Authors had a first version of their review study which was prepared a year ago and covered 66 primary studies published up to June 2015 but it was later updated to the 2016 version with seven additional studies from June 2015 to June 2016 being examined. Another SLR study (S23) particularly focusing on primary could adoption studies that were related to the trust factor included 28 articles published between 2012 and 2017 which aimed to model cloud adoption using trust as a factor in the final review pool.

Although S07 is not an SLR, it is a notable secondary study which aims to review the overall state of suggested cloud adoption models in previous primary studies with regard to used constructs/factors in their research model. Authors have examined 40 primary studies on cloud adoption in health care, education, and public sector and they summarized the factors these studies adopt.

As detected by the current SLR research, the first primary cloud computing studies (S12 and S14) that use SEM to test their hypotheses were published in 2009, mainly focusing on cloud adoption. S12 employs TCT while S14 combines TCT and TPB to construct their own cloud adoption model. Both studies have collected the user data from surveys targeting business companies.

After these first researches, only two additional cloud computing–SEM studies were published in the next four years. At that point, it can be seen that cloud adoption studies still focused on technology acceptance in organizations. S13 and S94 examine organizational cloud adoption further with data collected from managerial positions and IT executives. Other technology acceptance theories such as TAM and TRA began to be employed in cloud computing studies.

In 2013, non-business oriented cloud adoption SEM studies first appeared in the literature. In addition to S34 which analyzes cloud adoption in SMEs and S82 which analyzes cloud adoption amongst decision-maker IT professionals in their organizations; S85 examines cloud acceptance in government agencies, S33 targets university staff and students, and S26 is the first cloud adoption-SEM study in the article pool of this SLR on personal daily technology usage with their research focusing on Alibaba users and their e-commerce SaaS acceptance. TAM is the predominantly used technology acceptance theory in 2013, having been used in four studies out of five - in two of which it was used alone and in other two it was combined with UTAUT and TRA, respectively. On the other hand, S34 does not base their conceptual model on any specific technology acceptance theory.

A significant increase in the number of cloud computing – SEM studies is observed in 2014. As opposed to nine studies conducted in the previous five years, there are 13 cloud computing SEM studies published in 2014. Several studies focusing on adoption and use of diverse types of cloud services amongst different populations can be found in this year. Only one of these studies is on business-oriented cloud adoption. S62 examines cloud adoption in manufacturing and service sectors. Beyond business-oriented studies, increased variety of cloud study interests covered a wider range in 2014. S28, S50 and S72 study the adoption and use of health clouds and cloud computing in health care with different data sets collected from both patients and hospital and health care employees. S10, S16 and S61 are interested in cloud-based e-learning systems and the use of cloud in education and base their research on data collected from both students and teachers. For personal general cloud use in daily life, S65 aims to assess the adoption of mobile cloud services while S19 selects personal cloud storage services. S60 suggests a model to understand what affects the personal cloud use amongst university students while S06's model targets overall Internet users. Numerous technology acceptance theories, such as TAM, TOE, DOI, TRA and TPB, and several combinations of these theories are observed as a basis to the conceptual models in these studies.

In 2015, it is observed that the researches have shifted back to business-oriented cloud adoption in companies. Seven out of 12 SEM studies in 2015 were on cloud adoption and use in organizations. S17, S24, S31, S41, S48, and S68 all study factors affecting cloud adoption and use in organizations from different industries, in both public and private sectors. S37 aims to understand adoption of cloud federation (an agreement between cloud providers regarding deployment of their services) specifically, with data collected from business

organizations. S90 research studies the cloud computing in education using surveys conducted with heads of IT or their delegates at education institutions. S43 published a cloud computing–SEM study on health clouds. S73 bases their general cloud adoption for personal daily life use model on a data set obtained from students whereas S86 uses general cloud users' information for the same purpose. S89 examines factors that affect MBA students' cloud based collaborative tools adoption. Studies from 2015 used conceptual models both based on technology acceptance theories such as TAM, TOE and TPB, and based on general literature review without specifically employing one theory but instead selecting factors separately.

It is observed that the year with the highest amount of cloud computing–SEM studies (2016) holds 28 relevant studies with a heavy focus on business-oriented research. S49 and S58 examine SaaS usage in organizations. S18 and S80 specifically focus on cloud in supply chain management. S35, S36 and S52 research implementation of cloud based ERP tools in businesses while S51 is interested in CRM applications. S56 published their study on public cloud acceptance in companies. S53 focuses on logistics industry while S74 and S75 on specifically technology organizations. S81 researches security concerns of SMEs regarding cloud adoption. S01, S30, S32, and S46 are general cloud adoption studies in organizations from different industries. As for non-organizational studies, S84 and S59 use a data set collected from students to analyze cloud adoption in education while S77 and S40 base their model on teacher and university lecturer data. S44 suggests a health cloud acceptance and resistance model based on patient data. S15, S70, S08 and S47 all examine personal cloud use intention and continuation for different cloud services like storage or collaborative tools from students' perspective. S38 aims to analyze what affects hybrid cloud satisfaction. S54 selects a different study interest and analyzes what increases service quality of a cloud based tourism guide from customers' perspective. TAM is the theory employed most in 2016 studies, followed by TOE, DOI, and Social Cognitive Theory.

The year 2017 continued the trend of business-oriented study focus while, unlike previous years, not featuring any health cloud adoption studies. S20 focuses on cloud in supply chain management while S88 on cloud in logistics. S39 and S67 study cloud adoption intention in SMEs. S02 selects the cloud based ERP tools as the cloud technology to examine with data collected from companies that have been using cloud ERP for at least a year while S64 focuses on B2B cloud services. S04, S42, S55, S57, S69, and S71 all published general cloud adoption in organizations studies whereas S29 studies actual cloud use in organizations rather than fresh adoption intention. For cloud studies in the education domain, S09 surveyed students, S78 surveyed decision-makers at universities and S83 used a sample of students and teachers combined. S11 designs an adoption model for cloud computing in banking sector with a data set from bank customers. S66 surveyed students for a personal daily life use of mobile cloud services model whereas S92 and S95 used online communities and general cloud users for their personal cloud adoption and use studies. Majority of studies in 2017 did not base their research model on certain technology acceptance theories in literature and instead selected relevant factors independent from theory frameworks. The ones that based their models on theories mostly employed TAM, TOE and DOI.

In the first half of 2018 until the cut date for study selection of this review, there were 12 cloud computing–SEM studies completed. S63 researches manufacturing firms to understand the use and benefits of manufacturing cloud. S03 researches cloud data governance issues in public sector while S05 and S76 are interested in understanding cloud adoption in private sector. S21 and S22 design organizational cloud adoption models. S96 uses data collected from students to assess adoption factors for cloud based collaborative

educational tools, S93 uses data collected from students to model cloud-based learning resources adoption intention and S79 uses data collected from students to understand cloud adoption intention in universities to enhance education. In health-care domain, S45 specifically focuses on PharmaCloud and surveyed physicians for adoption intention data. S87 and S91 base their research model on general Internet users for cloud storage tools, cloud mail and cloud based office applications. In the first half of 2018, TOE framework is the theory most research models were based on, either alone or as combined with other theories like DOI and UTAUT.

The yearly distribution of cloud computing – SEM articles shows that there is a trend of increasing SEM usage in cloud computing studies over years. This can be explained by several factors. Most importantly, cloud computing as a technology in practical use got more and more popular after 2008 to the point of being an integral part of daily lives of individual users. During this time period, cloud as a technology also became a popular choice by firms at an organizational level. Organizations from different sectors and industries ranging from manufacturing, software, or technology to construction, health care and education with many more, This increased usage is reflected as increased academic interest in studying the adoption and usage of the technology. Another factor is the increased overall interest in SEM studies. With better computational capacity and software available, more complex models can be built and tested using SEM (Cudeck *et al.*, 2001).

Another observation that can be made by examining the trend of cloud computing – SEM studies is related to the study domains and the population samples chosen for data collection. Studies from the earlier years in the article pool mainly focus on cloud adoption in business environments, using surveys with organization employees or managers. More recent studies are found to be more varied in subjects as the cloud technologies gained interest from different domains like health care or education. In recent years, studies on continuous cloud usage are also conducted in addition to cloud adoption studies.

The rest of this section documents the answers to the research questions of the second goal of this SLR. Section 4.1 is related to *RQ2.1* and *RQ2.2*. Section 4.2 is related to *RQ2.3*, *RQ2.4*, and *RQ2.5*. Section 4.3 answers RQ2.6, Section 4.4 answers *RQ2.7*, and finally Section 4.5 answers *RQ2.8*.

### *4.1 Purpose of structural equation modeling and study domain*

The majority of cloud computing–SEM studies (76) deal with cloud adoption intention. Assessing the factors that affect adoption of a new technology by actual users in the system has been an important research area and SEM is a suitable statistical analysis technique for such studies. Out of the 92, 76 primary cloud computing–SEM studies in the article pool for this SLR focus on cloud adoption models and theories, whereas 16 studies assess actual ongoing cloud usage and factors that might motivate users to continually use the services or factors that affect the satisfaction of cloud services in use. Distribution of adoption and usage studies over years and over study domains is given in Table VII.

Four main study domains are found in the cloud computing–SEM studies in this review, namely *business*, *personal use*, *education*, and *health-care* domains. 50 of the primary studies focus on business and organizational cloud adoption and use cases. Business-oriented cloud research is followed by research of personal cloud usage in daily life with 19 studies. 14 primary studies are interested in cloud in education (high schools and universities) while six articles are about health-care systems and cloud computing in hospitals. Remaining three primary studies are interested in cloud usage in government, banking, and tourism sectors. Other four articles in the final pool are not primary studies but previous secondary studies and reviews on cloud adoption. Distribution of cloud computing–SEM studies over study

domains can be seen in Figure 7, whereas annual article counts from 2009 to first half of 2018 with regards to study domains is given in Figure 8.

*4.2 Surveys/questionnaires in studies*

All of the primary studies use a survey or questionnaire designed for the study to collect data from the target audience. The surveys have not always been conducted in the country of the authors but sometimes foreign or international samples have been used. Five articles do not specify the country from which the data were collected. Seven studies use international data collected online while three studies use European countries. Articles and the country of survey sample are given in Figure 4(b).

The number of the survey participants varies between articles. Sample size tends to increase when target audience for the survey gets less specific and when questionnaires are administrated online. Using professional survey agencies is another method to ensure increased participation. When the first five articles with the highest survey participation are examined, it is observed that four articles conducted their survey with general Internet

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Adoption* | | | | | | | | | | | | |
| B | 2 | 0 | 2 | 0 | 2 | 1 | 5 | 13 | 10 | 6 | 41 | 76 |
| P | 0 | 0 | 0 | 0 | 2 | 4 | 2 | 3 | 1 | 2 | 14 | |
| E | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 4 | 3 | 3 | 14 | |
| H | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 1 | 5 | |
| O | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | |
| *Usage* | | | | | | | | | | | | |
| B | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 3 | 0 | 9 | 16 |
| P | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 5 | |
| E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| H | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | |
| O | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | 2 | 0 | 2 | 0 | 5 | 11 | 12 | 28 | 20 | 12 | |

**Notes:** (B): Business. (P): Personal Use. (E): Education. (H): Health care. (O): Other

**Table VII.**
Annual article count per study domain and purpose

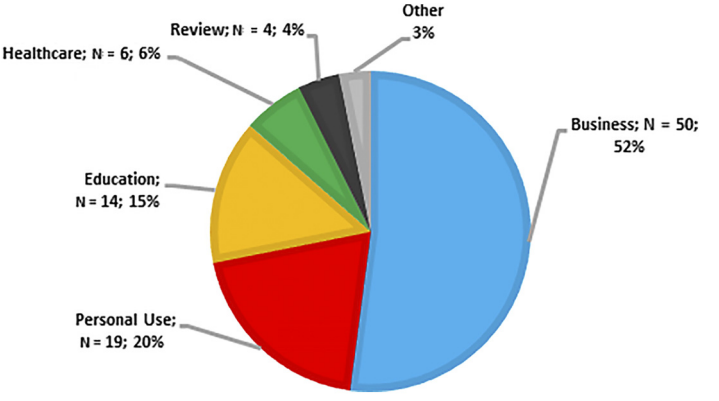


**Figure 7.**
Study domains where cloud computing–SEM studies are conducted

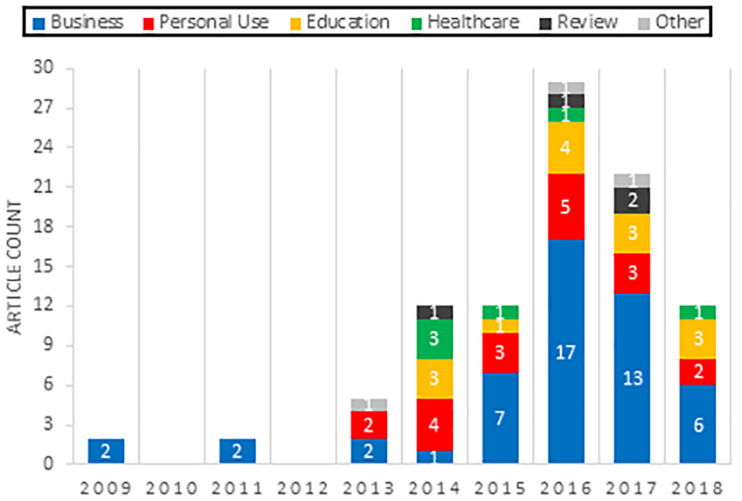


**Figure 8.**
Annual article count per study domain

users. S91 collected data from 2011 Internet users in Germany. S26 collected data from 1532 Alibaba customers internationally. S65 used a professional survey agency to collect data from 1099 Internet users with no country limitations. S40, fourth study with largest participation is the one that targeted a more specific audience and they conducted their data collection survey in 351 different schools, reaching out to 1064 teachers in Malaysia. S06 follows the aforementioned studies with a participant audience of 770 Internet users in Saudi Arabia. Survey participant numbers of reviewed studies is plotted in Figure 9.

Most selected samples for data collection are organization employees and managers at different levels, and students. First group's prevalence comes from the fact that majority of cloud computing–SEM studies are in business domain and students' prevalence comes from the fact that they are a suitable population for both educational cloud and personal cloud usage studies. 29 primary studies conducted surveys or questionnaire targeted at organization employees (with or without cloud experience or current actual cloud usage), samples of 14 studies consist of IT managers/specialists/experts at organizations and 11 studies surveyed specifically CEOs or managers of organizations. Only two of the studies are in education domain in which IT experts at universities are surveyed while 49 other studies in which managers or employees are surveyed focus on business-oriented cloud computing.

17 studies conducted surveys or questionnaire with high school or university students. Eight of the 17 studies are interested in cloud adoption or use in education environments while other nine are personal cloud use studies. Two of the studies surveyed teachers in addition to students. Three other educational cloud studies selected only teachers as their target population.

Regarding the health-care domain, two of the stories had collected the relevant data from health-care professionals and hospital staff (doctors, physicians, nurses, IT department) while two other health-care cloud studies surveyed patients.

Target population and samples of 10 articles consist of general cloud or Internet users with no specific job requirement. As having no specific target population requirements

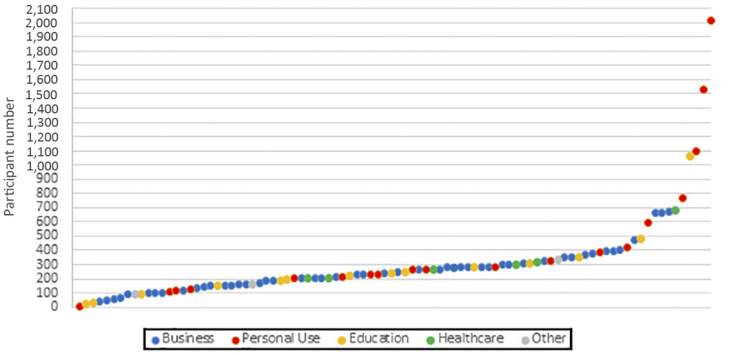


**Figure 9.**
Sample size of studies and domains of each study

implies, majority of these studies are on personal cloud usage in daily life focusing on services such as cloud storage, cloud based collaboration tools, etc. One study is in the education domain and one other is interested in usage of a cloud based tourism guide.

Numbers of studies with regards to their sample population and domains can be seen in Figure 10.

*4.3 Literature review by technology acceptance and behavior theories and model constructs/ factors*

The conceptual model used by researchers in their study may be based on theories and frameworks suggested in the literature or researchers can select the factors they find relevant to their study to construct their own model. 26 of the 92 primary studies examined in this review do not use any technology acceptance theory directly and they construct their models using individual factors taken from previous literature. 42 articles use a single technology acceptance or behavior theory to design their conceptual SEM model, 19 articles combine two different theories, four articles combine three different theories and one article combines four different theories and use hybrid models based on multiple theories.

Looking at only cloud adoption studies selected in the final article pool for this review, TAM is the most prevalently used technology acceptance theory. 26 of 76 cloud adoption

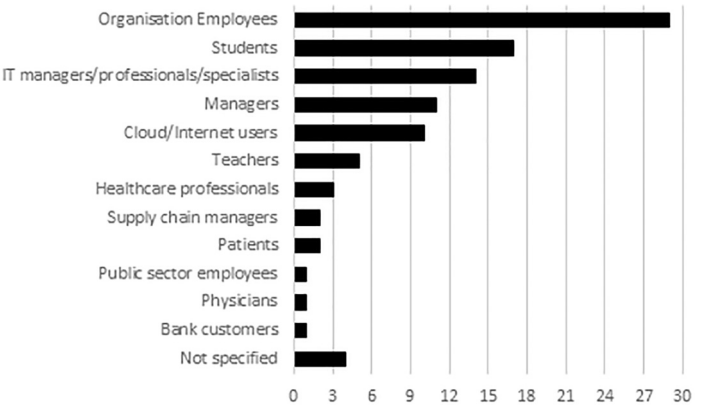


**Figure 10.**
Characteristics of study sample populations

SEM studies employed TAM either alone or in combination with other acceptance theories. TAM studies are followed by 17 adoption articles that do not base their models on certain previous theories. TOE framework is used in 15 different acceptance studies while DOI in 11 of them.

Cloud usage studies employ several different behavior theories when they base their models on previous frameworks. However, more often than not, they do not use such theories at all. Nine of the 17 cloud usage studies directly select factors that will be included in their models without certain frameworks to follow. Breakdown of all technology acceptance and behavior theories in all articles is given in Table VIII.

Constructing hybrid models that are based on several theories and frameworks is a common approach in the literature. As technology and behavior theories usually focus on certain aspects of the systems, combining theories gives researchers the opportunity to investigate a system of users through a multi-dimensional platform. For example, TAM structure can be enveloped into the TOE framework for a study conducted on people in an organizational environment so that the TAM constructs evaluate the individual's perceptions and intentions while TOE structure explains the organizational factors affecting these individuals. DOI is found to be the theory most commonly used together with other theories. S84 is the study with the highest number of theories (4) used for the hybrid model. Frequencies of the theory combinations can be seen in Figure 11.

| Theory | Count | Articles |
|---|---|---|
| TAM | 26 | [S09], [S84], [S77], [S94], [S08], [S42], [S85], [S65], [S86], [S19], [S26], [S47], [S15], [S33], [S59], [S11], [S82], [S73], [S93], [S78], [S83], [S32], [S30], [S31], [S06], [S60] |
| TOE | 15 | [S63], [S58], [S62], [S05], [S04], [S55], [S46], [S90], [S22], [S21], [S71], [S29], [S32], [S52], [S31] |
| DOI | 11 | [S84], [S77], [S58], [S62], [S79], [S04], [S22], [S21], [S78], [S67], [S60] |
| UTAUT | 7 | [S63], [S96], [S44], [S61], [S82], [S93], [S28] |
| TRA | 6 | [S84], [S13], [S33], [S92], [S52], [S60] |
| TPB | 5 | [S84], [S10], [S14], [S43], [S41] |
| 2FT | 3 | [S44], [S45], [S56] |
| TCT | 3 | [S80], [S14], [S12] |
| SCT | 3 | [S74], [S75] |
| SQB | 3 | [S44], [S45], [S43] |
| Expectation Confirmation | 2 | [S95], [S89] |
| Resource Based View | 2 | [S14], [S29] |
| Channel Expansion | 1 | [S40] |
| Cost-Benefit-Risk | 1 | [S24] |
| Dedication-Constraint | 1 | [S92] |
| Institutional | 1 | [S58] |
| Migration | 1 | [S16] |
| Push-Pull-Moor-Habit Model | 1 | [S50] |
| Self Determination | 1 | [S40] |
| Social Capital | 1 | [S20] |
| Social Influence | 1 | [S91] |
| Socio-technical Systems | 1 | [S49] |

**Table VIII.**
Theories and articles in which they are used

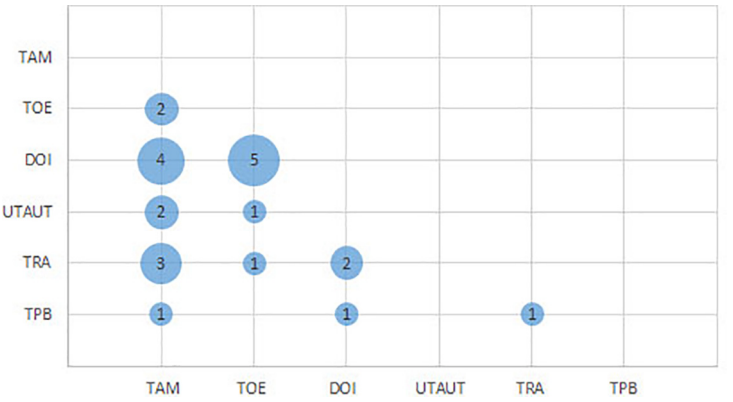


**Figure 11.**
Frequencies of theory and framework combinations

TAM theory is used in all study domains except health care. 11 of the 26 studies that employ TAM are on personal cloud use and adoption cases. Seven TAM studies focus on educational use of cloud, six TAM studies are interested in business-oriented cloud adoption and use models.

TOE framework, as the organization-focused nature of the theory implies, is most used in business-oriented cloud studies. 14 of 15 TOE occurrences in cloud computing SEM research are in business-oriented studies. Only other TOE usage is found in a cloud study conducted in the education domain, where the organizational factors in the model (which are traditionally used to determine the perspective of managers and employees in the organization) are used to understand the education institute's perspective.

Similar to TOE, DOI is commonly used in organizational cloud studies in the business domain. Six of 11 DOI studies are business-oriented cases, whereas four cloud studies in the education domain and one research on personal cloud usage are based on the DOI theory.

Other theories can be found to be used evenly in studies in all different domains, number of theories used in study domains can be seen in Figure 12.

*4.4 Results of structural equation modeling in primary studies*

SEM technique requires a conceptual prior model defined by researches to test the hypotheses. Whether researchers base their model on previous theories in literature or they build their research model with a focus on only separate factors, their conceptual models have constructs (causal factors and dependent variables that are affected by these factors) defined by authors prior to SEM application. As a result of SEM analysis, some of the pairwise relationships of these constructs will be rejected as statistically insignificant and some will be accepted.

In the literature of cloud computing–SEM studies, 93 primary studies use 261 unique causal factors and 56 unique dependent variables affected or caused by the causal factors. 261 unique causal factors occur 692 times in the research models of all articles whereas 56 unique dependent variables occur 125 times. Every conceptual SEM model has more than one causal factors and at least one dependent resulting variable. Each pairwise relationship between causal factors and dependent variables, causal factors and other causal variables, or dependent variables and other dependent variables is represented as a hypothesis to be tested with SEM.

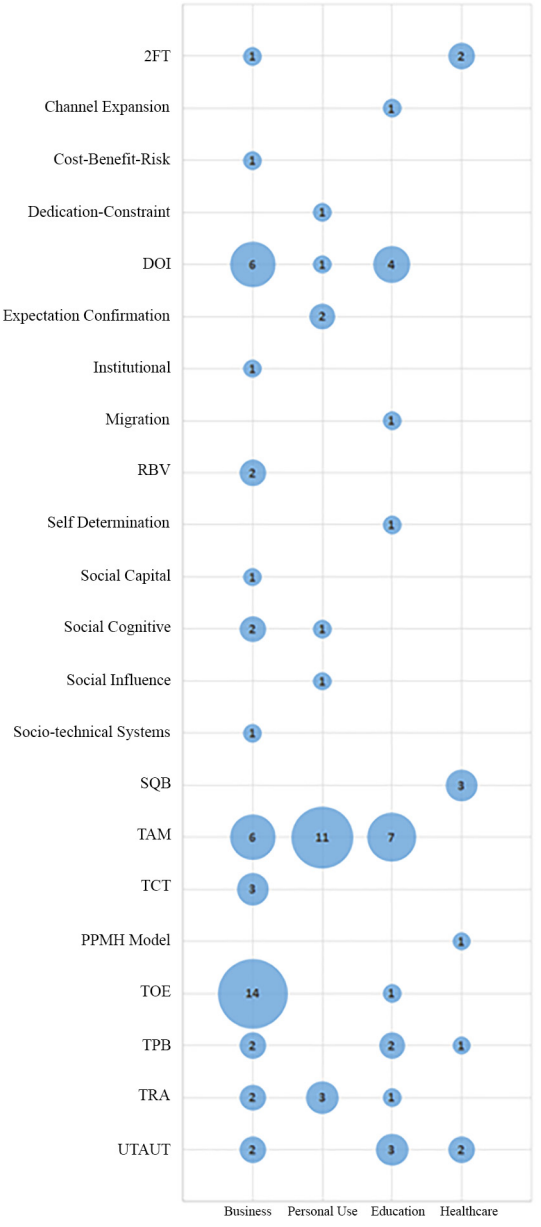


**Figure 12.**
Theories and study domains in which they are used

After SEM technique is applied to the conceptual prior model and data collected with surveys, the hypotheses are found either statistically significant or insignificant. When a hypothesis that suggests a relationship between a causal factor and dependent resulting variable is accepted (it can be directly or indirectly), the causal factor is considered

significant. Here directly means the causal factor has a direct significant effect on the dependent variable and indirectly means that causal factor has an effect on another causal factor that then affects the dependent variable. Out of all causal factors suggested and tested in 93 primary studies, 223 different factors are found significant and 77 different factors are found insignificant. The total exceeds the aforementioned unique factors count, 261, because there are cases of the same factor having been found significant in one study and insignificant in the other.

"Security and Privacy" is the most commonly used causal factor in the conceptual prior models. 32 of the 93 primary studies used Security and Privacy in their models. "Costs", "Ease of Use and Convenience" and "Risks" follow "Security and Privacy" with 26 occurrences each. "Usefulness" is used in 25 different prior models, "Trust" in 19, "Compatibility" in 15, and "Relative Advantage" in 13. "Company Size", "Complexity", and "Top Management Support" appear in prior models of 12 different studies. "Social Influence" and "Subjective Norm" are used in 11 studies, "IT Experience and Skills" in 10 and "Benefits" in 9.

"Security and Privacy" is also the factor that is found significant in most cases. 27 studies of the 32 (84.3 per cent) that use "Security and Privacy" in their prior models concluded after the SEM analysis that "Security and Privacy" has a significant effect on the dependent resulting variable of their models. "Ease of Use and Convenience" is found significant in 24 (92.3 per cent) studies whereas "Usefulness" is found significant in 23 (92 per cent) studies. Out of 26 studies that have "Risks" in the prior model, 20 (76.9 per cent) different ones find it a significant factor. Out of 26 studies that have "Costs" in the prior model, 19 (61.5 per cent) different ones find it a significant factor. Effect of "Relative Advantage" and "Top Management Support" on the dependent variables is found significant in 11 (84.6 per cent and 91.6 per cent, respectively) different studies. The number goes down to 10 (66.6 per cent, 83.3 per cent, and 90.9 per cent, respectively) for significant "Compatibility", "Complexity", and "Social Influence" factors. "Company Size" and "Subjective Norm" are found significant in 9 (75 per cent and 91.6 per cent, respectively) studies, "Benefits" in 8 (88.9 per cent), and "IT Experience and Skills" in 6 (60 per cent) different studies. The list of most commonly suggested causal factors and their acceptance and rejection percentages can be seen in Table IX.

**Table IX.**
Most commonly used constructs and factors

| Suggested Causal Factor | Occurrence | Occurrence (%) | Acceptance | Rejection | Acceptance (%) |
|---|---|---|---|---|---|
| Security and Privacy | 32 | 34.78 | 27 | 5 | 84.38 |
| Costs | 26 | 28.26 | 19 | 7 | 73.08 |
| Ease of Use and Convenience | 26 | 28.26 | 24 | 2 | 92.31 |
| Risks | 26 | 28.26 | 20 | 6 | 76.92 |
| Usefulness | 25 | 27.17 | 23 | 2 | 92.00 |
| Trust | 19 | 20.65 | 19 | 0 | 100.00 |
| Compatibility | 15 | 16.30 | 10 | 5 | 66.67 |
| Relative Advantage | 13 | 14.13 | 11 | 2 | 84.62 |
| Company Size | 12 | 13.04 | 9 | 3 | 75.00 |
| Complexity | 12 | 13.04 | 10 | 2 | 83.33 |
| Top Management Support | 12 | 13.04 | 11 | 1 | 91.67 |
| Social Influence | 11 | 11.96 | 10 | 1 | 90.91 |
| Subjective Norm | 11 | 11.96 | 9 | 2 | 81.82 |
| IT Experience and Skills | 10 | 10.87 | 6 | 4 | 60.00 |
| Benefits | 9 | 9.78 | 8 | 1 | 88.89 |

As for dependent variables that are affected by other independent or dependent factors and are defined as the end goal of the prior models, "Cloud Computing Adoption" is used in 28 studies. "Intention to Use Cloud Computing" appears in models of 16 studies while "Actual Usage of Cloud Computing" is used in 14 models. Dependent variables of primary studies are given in Table X.

*4.5 Limitations of primary studies and suggested future work*

63 of the 92 primary studies in the article pool of this SLR mention the possible limitations of their work and suggest future studies based on the limitations. Limitations of SEM studies on cloud computing can be categorized under six groups (numbers in parentheses are numbers of articles that specified limitations of that category):

*Model/theory/method limitations (54 studies)*: Although there are several technology acceptance and behavior theories that can be used to build the conceptual models and also numerous different factors that can be used as constructs in the conceptual models, studies select one theory or a combination of two or three theories on which they base their models. Using a different theory or different constructs in the model could possibly give better and more accurate results, thus the model/theory/method used in the study might be a limitation.

*Sample limitations (39 studies)*: Besides geographical limitations of data collection, surveys are also conducted with certain focus groups, such as students, IT managers, or patients. For example, generalizing findings based on a survey conducted with students to make statements on teachers' behavioral intention might not be accurate. Not only characteristics but also size of the sample might be a limitation in some studies. If sample size is too small, it might lead to false acceptance or rejection of hypotheses.

*Geographic location limitations (35 studies)*: Researchers conduct the data collection surveys in certain countries. Since SEM studies are mainly based on human behavior and intention, the results of the same study may differ largely between different countries and regions. Having a geographically restricted data might be a limitation to generalize findings.

*Industry limitations (20 studies)*: Behavior and the perception of people in different industries towards a new technology may be different. If a SEM study on cloud computing is completed using data collected from the software development industry, it might not give accurate results for making statements about cloud acceptance in the manufacturing industry.

*Time frame limitations (19 studies)*: If the dataset of the study is cross sectional, it means data were collected and measured at one single point of time instead of observing the behavior of the sample over time and measuring the different responses. This might be a

| Conceptual dependent variable | Occurrence | Occurrence (%) |
|---|---|---|
| Cloud computing adoption | 28 | 30.43 |
| Intention to use cloud computing | 16 | 17.39 |
| Actual usage of cloud computing | 14 | 15.22 |
| Continuance intention | 5 | 5.43 |
| Business performance | 3 | 3.26 |
| Cloud computing usage behavior | 3 | 3.26 |
| Firms operational performance | 3 | 3.26 |
| Behavioral outcome | 2 | 2.17 |
| Enterprise usage intention | 2 | 2.17 |
| Loyalty | 2 | 2.17 |
| Resistance to use | 2 | 2.17 |

**Table X.**
Most commonly used dependent variables

limitation to generalize findings as a study conducted at the early stages of cloud computing might give significantly different results than a study conducted years after cloud computing is more generally accepted as a tool.

*Cloud service type limitations (12 studies)*: SEM studies might focus on one single cloud service or a certain group of cloud services. Using the findings of a SEM study that focuses on people's acceptance of cloud collaboration tools to make statements about people's acceptance of cloud storage services might be misleading.

### *4.6 Open issues*

SLR studies are useful tools for researchers who want to understand the current state of research in a certain domain and see the research gaps without having to investigate every single primary study conducted so far. Looking at the current state of the literature as a whole through the results of this study, a number of open issues can be pointed out to those who are interested in further researches in cloud computing domain.

The increasing cloud computing usage in different areas is reflected in the studies completed so far only to an extent. Cloud adoption studies are not limited to business environments anymore; studies that examine the technology adoption in different areas like health care or education are also being conducted. However, cloud technologies today are even further specialized for specific areas and domains and there are specialized cloud solutions for many different business and daily life needs. Further cloud adoption and usage studies may choose to focus on these specific domains instead of general business adoption, for example adoption of cloud for software development.

Technology adoption studies are usually conducted for a specific group of people because the social and cultural differences of different groups affect their perception regarding that technology. However, cloud computing is a "borderless" technology by its nature and cloud services are accessed and used by different groups in a similar way. Therefore, a study combining populations from different cultures and backgrounds on a common cloud technology might prove interesting results that are focused on the technology itself rather than the differences between user groups.

In the cloud adoption and usage studies so far, a distinction between potential cloud services and models to be adopted is not specified. Different cloud services like IaaS, PaaS or SaaS or different cloud deployment models like public, private or hybrid clouds are, by their definition, not alike. Adoption intention and perception amongst users might change for different cloud services and models. Conducting a research based on the distinctions on the characteristics of cloud services and deployment models are might give different but valuable results.

The collected data of the studies in the article pool of this SLR are cross-sectional. 19 of the studies specifically point this as a potential limitation and suggest future studies with the same sample for the same technology to measure the changes in their behavior over time. However, such a longitudinal study is not yet found in the literature of SEM studies for cloud adoption or usage cases. Completed studies can be repeated to observe the changes in use behavior.

## 5. Conclusion

SLRs are useful studies to summarize the current state of academic literature in a specific area as guidance for future researchers (Kitchenham, Brereton and Budgen, 2010). This SLR study focuses on SEM studies in cloud computing area within information systems domain. Findings can be used to understand the previous research efforts and to plan future works.

Since practical use cases for cloud technologies began to be realized more commonly in the late 2000s, researchers in information systems domain were interested in adoption studies and SEM was one of the first statistical techniques used in the early studies. As it has been observed in the findings of this SLR, over years the number of cloud computing–SEM studies have increased significantly.

It is found that SEM is used in both cloud adoption and cloud usage studies. Findings of this study show that models and sets of hypotheses to understand factors affecting both adoption of cloud as a new technology and continuous use of cloud services are tested using SEM as the statistical analysis method. The adoption and usage cases are taken from mainly four different study domains: business, personal use, education and health care.

Technology acceptance theories and cognitive behavioral theories are employed in adoption studies whereas the latter ones are also used in usage studies. TAM is found to be the most commonly used theory in designing conceptual research models. In the SEM models based on these theories or standalone constructs; cloud adoption, intention to use cloud, and actual usage of cloud are the most commonly found dependent variables. SEM analysis tests the effect of causal factors on these dependent variables. Most commonly suggested causal factors are found to be security and privacy concerns, costs, ease of use, risks, and usefulness. Ease of use and usefulness are core parts of TAM structure so it is not a surprising result that they are two of the five most suggested constructs.

Adoption of use of technologies by users in practice is a certain part of a larger cyclical ecosystem in which research is conducted on real social life cases to understand and further improve them. This system structure contains academic research, as well as practical use of technology by individuals and organizations. In this study, the system of cloud adoption and usage is analyzed and the current state of literature is examined with regards to the components of the system and their interactions. Results are given in a structured manner. It is possible to draw further conclusions from the results of this SLR study that are beneficial to both academic researchers and technology providers and users.

A recommended future academic research after this SLR is to conduct a review study to focus on cloud adoption and usage studies that do not use SEM and instead use different statistical methods. With such a study, comparisons between SEM and alternative methods in similar studies may be analyzed. Following this, the findings can be used to obtain more valuable results, such as "what factors motivate researchers to use SEM in which cases" and "what conceptual models on which cloud services and which populations are more suitable to SEM or to other statistical analysis techniques". Such results would allow the researchers to better plan the methodology of their studies according to the characteristics of their planned research. As for the primary adoption and usage studies in cloud computing domain, Open Issues section of this study summarizes the current state of the literature with the focus on the future primary study suggestions.

Implications of this study for technology developers and cloud providers can be seen as that users' reluctance to use cloud solutions to local, physical alternatives mainly is related with their privacy and security concerns. Cloud providers might want to focus on changing users' perceptions regarding the safety of cloud services while ensuring their privacy.

The users within the system, which may be either individual users or large-scale organizations, might find valuable information from the tested models and hypotheses in different studies focusing on different areas of cloud use and the confirmed relationships and significant factors in these studies. Comparing the results of studies in several domains

such as business or education, users and managers might find some assistance in cloud-related decision making processes.

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