A STRUCTURAL EQUATION MODEL FOR UNDERSTANDING THE USE OF CLOUD BY SOFTWARE DEVELOPMENT TEAMS

YAZILIM GELİŞTİRME TAKIMLARININ BULUT KULLANIMINI ANLAMAYA YÖNELİK BİR YAPISAL EŞİTLİK MODELİ

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ERHAN PİŞİRİR

ABSTRACT

A STRUCTURAL EQUATION MODEL FOR UNDERSTANDING THE USE OF CLOUD BY SOFTWARE DEVELOPMENT TEAMS

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Supervisor: Assoc. Prof. Dr. Oumout Chouseinoglou

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The primary research of this thesis is a technology adoption study which particularly focuses on cloud technologies in software development activities. Structural Equation Modelling (SEM) is used to test the conceptual model which is designed with inclusion of novel suggestions to theories in the existing literature. Before this main primary research, a detailed systematic literature review (SLR) is presented on cloud computing studies that use SEM as the statistical analysis method.

This SLR summarises the current state of literature by analysing previous studies and methodically categorises them. In the scope of SLR, 96 cloud computing studies from 2009 to June 2018 that employed SEM obtained from four online databases are selected and relevant data are extracted to answer the research questions. 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 healthcare. Technology Acceptance Model (TAM) is found to be the most commonly used theory. Adoption, intention to use, and actual usage are the most commonly selected dependent variables in SEM models whereas security & privacy concerns, costs, ease of use, risks, and usefulness are the most common selections for causal factors.

Technology adoption studies are, in essence, social behaviour studies that aim to understand effects on behavioural intention to adopt or use innovations. In this thesis, a hybrid model is designed and tested in order to understand the changes in software developers' intention to adopt cloud for their software development activities. This hybrid model consists of factors taken from TAM and Technology-Organisation-Environment (TOE) theories. In addition to these, novel suggestions are included in the model under the name of Personal-Organisation-Project (POP) structure. The reason for the novel suggestions is that the characteristics of projects are predicted to affect the project team members' intention to use cloud in their work even in the same organisation.

Upon completing the initial statistical analyses, 15 of the 21 initial hypotheses in the model are accepted with high significance levels. Then the rejected hypotheses are removed and the model is modified with exploratory SEM analyses and a revised final model is reached. 16 new regression relationships between variables are discovered. Discovered effects are discussed and ensured to be logically consistent and reasonable in real life systems. In the end, the hybrid model itself is validated as a technology adoption model and specific conclusions are drawn for developers' intention to use cloud in software development organisations in Turkey.

Keywords: Technology adoption, Cloud computing, Software development, Structural equation modelling, Exploratory factor analysis.

ÖZET

YAZILIM GELİŞTİRME TAKIMLARININ BULUT KULLANIMINI ANLAMAYA YÖNELİK BİR YAPISAL EŞİTLİK MODELİ

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Bu tez, yazılım geliştirme aktivitelerinde bulut bilişim teknolojilerinin kullanımını inceleyen bir teknoloji kabul çalışmasıdır. Teknoloji kabulünü incelemek amacıyla, bu çalışmaya özgün bir model yapısının literatürdeki teorilere dayanan değişkenlerle birleştirilmesiyle oluşturulan bir hibrit model, istatistiksel araç olarak yapısal eşitlik modeli kullanılarak test edilmiştir. Bu asıl çalışma öncesinde, bir sistematik literatür taraması sunulmuştur.

Sistematik literatür taraması, bulut teknolojilerinin kabulü ve kullanılması üzerine yapılan ve Yapısal Eşitlik Modeli (YEM) kullanan çalışmaları incelemiş, gruplamış ve özetlemiştir. Dört akademik veri tabanı detaylı bir şekilde taranmış ve 2009 ve Haziran 2018 arasında yayınlanmış 96 çalışmaya ulaşılmıştır. Teknoloji kabul çalışmalarında YEM kullanımının zamanla arttığı görülmüştür. Teknoloji benimseme çalışmaları, sürekli kullanım çalışmalarına göre daha yaygın olmakla birlikte, bu çalışmalar dört ana

alan altında gruplandırılabilmektedir: kurumsal, kişisel kullanım, eğitim ve sağlık. Teknoloji Kabul Modeli (TAM) en yaygın kullanılan teori olarak bulunmuştur. Çalışmaların kurduğu modeller en yaygın olarak teknoloji kabulü, kullanım isteği ve mevcut kullanımdaki değişiklikleri ölçmeyi amaçlamaktadır. Bu amaçla en yaygın kullanılan faktörler güvenlik kaygıları, maliyet, kullanım kolaylığı, riskler ve kullanışlılık olarak tespit edilmiştir.

Teknoloji kabul çalışmaları sosyal davranışları ölçen çalışmalardır. Bu tez çalışmasında, yazılım geliştiricilerin yazılım geliştirme aktivitelerinde bulut teknolojileri kullanma isteğini etkileyen faktörlere dayalı bir model oluşturulmuştur. Bu model literatürde mevcut olan Teknoloji Kabul Modeli (TAM) ve Teknoloji-Organizasyon-Çevre (TOE) teorilerine dayanmakla birlikte, bu çalışmada önerilen özgün model yapısı da Birey-Organizasyon-Proje adı altında geliştirilmiştir. Aynı kurum içinde farklı karakteristiklere sahip projelerde bulut kullanım isteğinin farklı olacağı öngörülmüştür.

İstatistiksel analizler sonucunda, çalışma kapsamında önerilen 21 hipotezin 15'i yüksek anlamlılık dereceleri ile kabul edilmiştir. Reddedilen altı hipoteze dair ilişkiler modelden çıkarılıp model keşifsel YEM analizi ile güncellendiğinde 16 yeni ilişkinin anlamlı olduğu ortaya çıkmıştır. Keşfedilen yeni ilişkilerin mantıklı ve tutarlı olduklarından emin olunduktan sonra modelin son haline ulaşılmıştır. Bu sayede, hem önerilen hibrit teknoloji kabul modelinin kullanışlılığı onaylanmış, hem de Türkiye'deki yazılım geliştiren organizasyonlarda çalışan yazılım geliştiricilerin bulut kullanma isteğine dair yorumlara ulaşılmıştır.

Anahtar Kelimeler: Teknoloji kabul teorisi, Bulut bilişim, Yazılım geliştirme, Yapısal Eşitlik Modeli, Keşifsel faktör analizi.

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SYMBOLS AND ABBREVIATIONS

Symbols

Abbreviations

DOI	Diffusion of Innovation Theory
POP	Personal-Organisation-Project
SCT	Social Cognitive Theory
SDO	Software Development Organisation
SEM	Structural Equation Modelling
TAM	Technology Acceptance Model
TOE	Technology-Organisation-Environment
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology
IaaS	Infrastructure as a Service
PaaS	Platform as a Service
SaaS	Software as a Service
FaaS	Function as a Service

1. INTRODUCTION

Technological innovations start as an idea upon observing the current social state and trying to answer questions such as how something can be done better, how a specific need can be fulfilled, or how a problem can be solved. After the initial idea, they are realised, developed, tested, and when they are ready, presented to potential users. The users here might be the public, individuals, organisations, governments, or any parties that will benefit from using the innovation. Acceptance of new technologies by these parties is not generally immediate. Users must be able to justify the change to themselves in order to adopt new innovations over the current methods or technologies they have been using.

With new technologies becoming more practical for individual use, there has been an increase in technology adoption studies that aim to understand what affects users' intention to accept a new technology or to keep continuously using it afterwards. Technology adoption studies are information systems research as much as they are social and behavioural studies. Specific technology or innovation and the selected population might result in different conclusions between studies. At the same time there are generally accepted theories and models that can be used in these different technology adoption studies to reach statistically significant results.

This thesis is a technology adoption study which specifically examines the adoption and use of cloud technologies in software development activities in Turkey. The population is selected as the software developers working in current software projects in organisations in Turkey. The conceptual technology adoption model is designed by integrating a novel structure to factors based on accepted technology adoption theories in literature. In addition to the technology adoption research, this thesis in its first part presents a detailed and methodical systematic literature review on previous cloud adoption studies to understand the aforementioned increase in these studies and the trends in the light of cloud computing as the particular innovation.

This study consists of two parts. The first part is a systematic literature review (SLR) focused on previous studies that analyse adoption and use of cloud technologies by employing structural equation modelling (SEM) technique. The literature review aims to summarise the current state of cloud computing – SEM studies with a systems thinking approach so that the results can be beneficial to different parties in the social system such as end users, cloud providers, and future researchers. This social system has a cyclic structure of social facts and beliefs, information and knowledge, and further social facts and beliefs which progresses with researches extracting information from social observations.

The second part is the novel primary research conducted within the context of this thesis. The primary research is a technology adoption study focused on the acceptance of cloud technologies in software development projects. The target population selected for this study is software developers, project managers, and senior executives in organisations that develop software as either their primary or secondary area of interest. Hereinafter, these organisations will be referred to as software development organisations (SDOs) In the rest of this study. A conceptual cloud adoption model is proposed, parts of which are based on previous technology adoption and behavioural theories in the literature and other parts of which are the novel contributions of this study. A questionnaire consisting of items to measure factors in the conceptual model is designed and personally administered to 191 unique participants from 30 different SDOs working in 84 different software projects. The collected data is cleaned and prepared for statistical analyses and SEM is employed to conduct confirmatory and exploratory analyses in order to derive the final adoption model for cloud technologies in software development activities.

Even though it is observed from the first part of this study that there have been numerous studies to analyse the acceptance of cloud as a new technology in the last decade, to the best of our knowledge currently there does not exist a study examining the acceptance of cloud technologies in software development activities. The primary research in this thesis aims to conduct a study to address this gap in literature and also put forward a guideline to understand the factors that affect cloud adoption in software development activities in Turkey.

In the remaining parts of the first chapter, the general concepts on which this study focuses are defined. In the second chapter; the conducted SLR, its results, and conclusions are explained in detail. In the third chapter; the methodology for the primary research is defined and theories, models, and statistical tools used in the study are explained. In the fourth chapter, statistical data analyses are conducted and the findings of the study are presented in detail. In the last chapter, conclusions that are drawn from both parts of this thesis study are shared and interpreted.

1.1 Software Development

A software is a computer program coded in order to perform an operation as well as all the documentation related to the program [1]. There may be a need to solve a logical problem, or a need to improve how a certain operation is performed. This is when the initial concept for a specific software begins. Developers who might need the software to solve a problem of their own or for the needs of a customer analyse what the requirements for the software are. With these requirements in mind, they begin designing the concept of the software. Once the software is coded and ready to run, it does not reach the end of its life cycle. There are maintenance efforts still needed during its runtime.

Software projects are conducted to develop, test, and maintain software. A software project consists of several phases. It is not only the activity of coding the software but it is a process which starts with gathering the requirements and conceptual design, and finishes with continuous maintenance of the product. The knowledge areas listed in Guide to the Software Engineering Body of Knowledge [2] can be considered as foundations to different activities in a software development project. Based on these knowledge areas and [3], the different phases of a software project are defined as the following: Main activities in a software project are requirements management, design, development, test, deployment, and maintenance. There are also other activities in software projects such as configuration management, documentation, quality assurance, and project management. Depending on the software development model chosen for the project, these activities and phases can go sequentially, in parallel, or in iterative cycles. Some of the activities like documentation can occur in every phase of the project.

The activities like documentation, quality assurance, or project management can occur in different types of projects. However, software projects have enough differences than other traditional projects that they might need different management approaches to successfully complete them. Some reasons for this are [4][5]: unlike traditional physical manufacturing products, software is an intangible product that is the result of a human-based development process; if communication between the project team members is unclear, it might lead to larger development failures than traditional projects; initial requirements might change and evolve over the course of the project; and as the software product is not limited by physical laws it can get infinitely large and complex to maintain.

Many solutions are born from the need for a different approach to project management in software projects. For the most part, these solutions were traditional and local solutions such as buying and using proprietary software packages to handle different activities in a software project like scheduling, requirements gathering, testing, etc. In the last decade, with cloud computing becoming more popular and easier to access / use, cloud-based alternatives to these software packages emerged.

1.2 Cloud Computing

Cloud computing as an idea is not a new concept, however, it became realistically practical only in the last decade with the developments in hardware and the computing capacities, the global Internet Infrastructure, and virtualisation technology [6]. In its essence, cloud computing is distributing services to end users who connect to the system by having such services hosted on a mainframe server. The definition that The National Institute of Standards and Technology (NIST) uses for cloud computing is as follows:

> *"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing*

> *resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."* [7]

Cloud services are developed and presented to users by cloud providers for both organisational 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).

Main services offered using cloud technologies have been infrastructure, platform, and software as a service (IaaS, PaaS, and SaaS, respectively). In recent years the cloud services began being more direct solutions to specific needs and problems and the variation of cloud based systems increased significantly. Cloud solutions for software development activities are an example of these specific cloud services. There are cloud computing solutions that could be considered more traditional, such as renting a virtual machine as a PaaS model for a programming or deployment environment as well as solutions that rely on more recent technological developments like Function as a Service (FaaS) and algorithm libraries that can be used during software projects.

Cloud technologies can replace or co-exist with local traditional solutions in every phase of software development projects. Some activities have more straightforward cloud-based solutions such as documentation or project management which might be easier to migrate to cloud. On the other hand, migrating development (coding) or testing activities to cloud might take more effort to get used to and might initially cost more because it is essentially a new environment to complete the tasks developers were used to handle traditionally. Even with the complexity and initial cost barriers, such migrations might prove successful in the long term.

With all the factors in mind, it can be said that no alternative is the be-all end-all solution in software development activities. Factors like complexity, cost, or data security and safety concerns push the developers and users to one way or the other when it comes to adopting new cloud-based innovations over traditional methods. Technology adoption studies are useful in this regard to model and understand users' behavioural intention to use a new technology and what factors affect this intention in which circumstances.

1.3. Main Research Questions

The motivation of this thesis can be defined with the main research questions that are aimed to answer with the results of the study. Main research questions can be listed as:

Q1: How do factors derived from the personal perceptions and characteristics of organisation, project, environment, and technology affect users' intention to use cloud in software development activities?

Q2: What is the current state of cloud usage in software development activities in SDOs in Turkey?

Q3: What do the previous cloud adoption studies focus on? What is the current state of literature regarding cloud computing - SEM studies?

Q4: Is structural equation modelling (SEM) an appropriate statistical method to analyse intention to use cloud?

Q3 and Q4 are answered by conducting an extensive systematic literature review. This review summarises the current state of cloud computing - SEM studies. It also shows that SEM has been a statistical technique used for cloud adoption studies with significant and valid results and an adoption study on cloud technologies in software development activities will be a novel addition to the current literature.

Q1 and Q2 are the main research questions related to the primary study part of this thesis. Q2 is answered with the questionnaire used to collect data from software developers, project leaders, and senior managers in SDOs in Turkey. The data collected with this questionnaire is also used in statistical analyses to test and validate hypotheses regarding Q1 as the result of this thesis.

2. LITERATURE REVIEW

2.1. Use of Structural Equation Modelling in Cloud Studies

There are numerous studies in the literature that analyse 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 employed SEM as the statistical analysis tool. The main motivation of conducting the SLR section of this thesis study is to review these researches, therefore the current state of SEM studies in the cloud computing domain, to summarise 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 literature review 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 review 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. As a result, an SLR was conducted, which to best of our knowledge is the first SLR of SEM usage in cloud computing studies. The full details of this SLR is given in [8].

Two main goals are defined before conducting this SLR. Firstly, we try to identify the current state of literature of SEM studies in the cloud computing domain. Secondly, 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 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?

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(s) did the authors conduct the questionnaire/survey to collect data?

RQ2.6: Which theory(s) 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?

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 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 [9]. 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.

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

(1) Study is about cloud computing.
(2) Study uses SEM to analyse results.
(3) Study is a review/SLR/secondary study in this area.

Similarly, the initial exclusion criteria are:

(1) Study is not about cloud computing.
(2) Study does not use SEM to analyse results.
(3) Result is not a journal article or a conference proceeding.
(4) Article is not in English.

(5) 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.

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 Appendix 1 with the purpose of assigning IDs to be used in the rest of this study. The steps followed in this SLR are graphically summarised in Figure 1.

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 2.

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, healthcare, personal use). The distribution of studies from different countries on different study domains can be seen in Figure 3a.

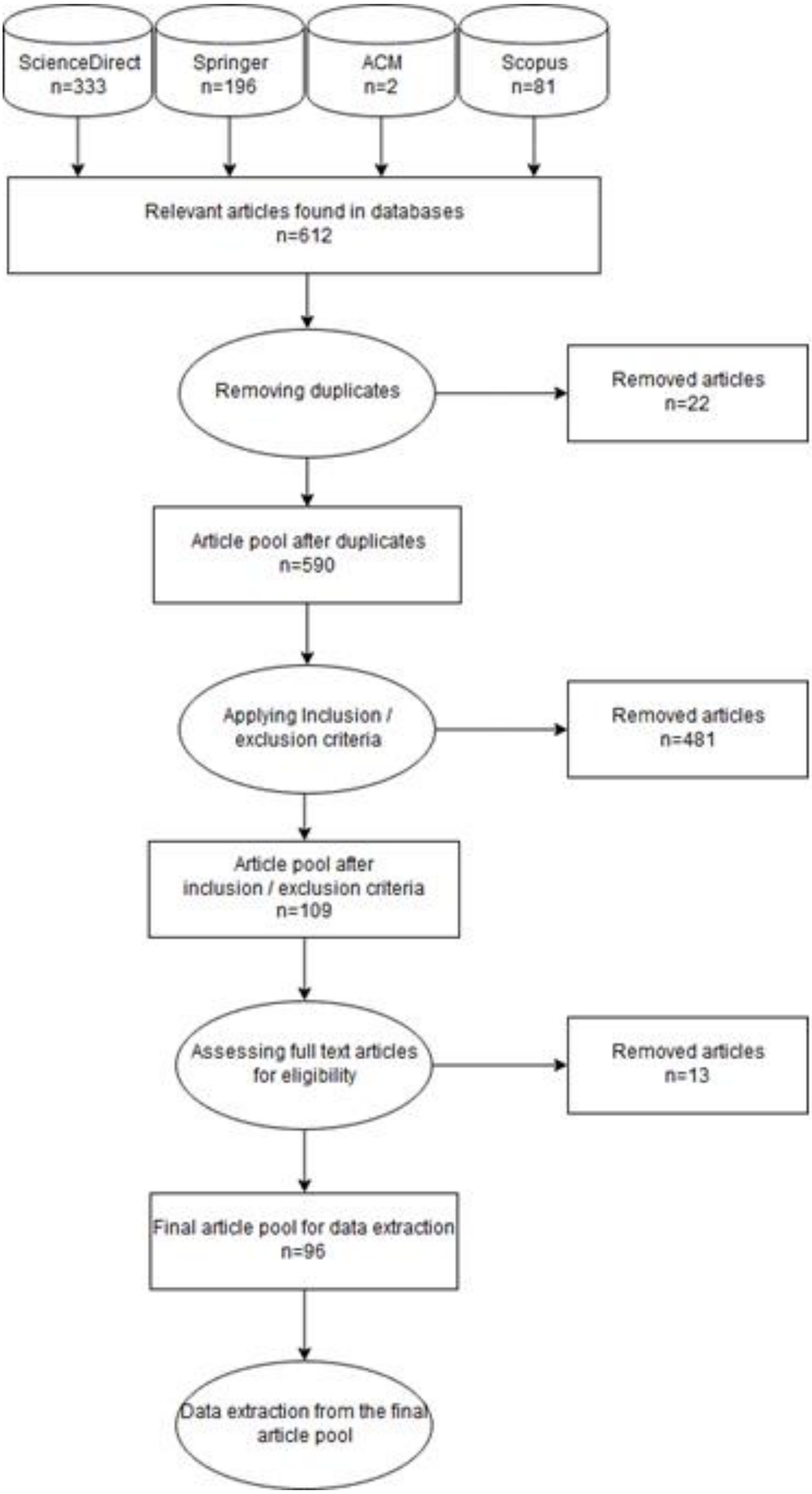

Figure 1: Steps of the SLR study

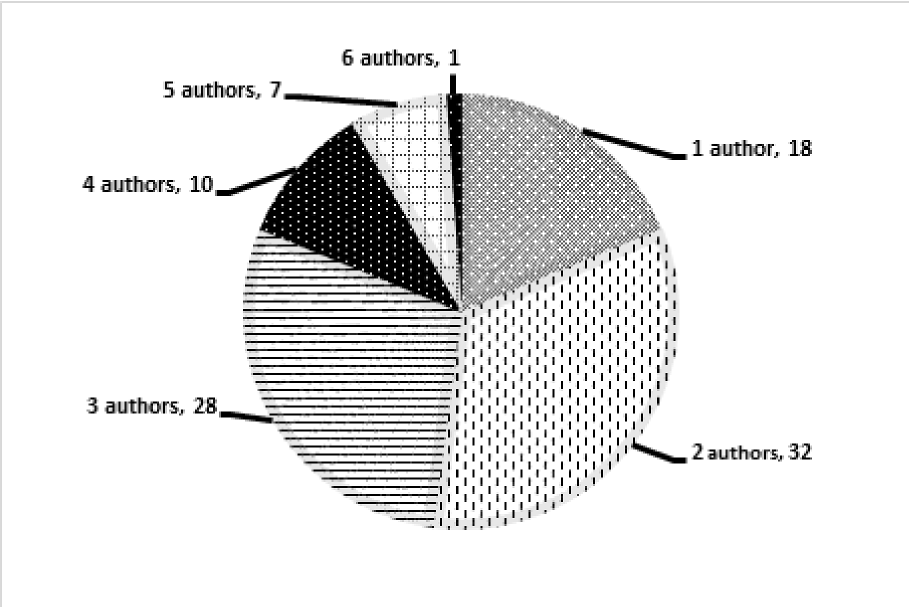

Figure 2: Author numbers per article

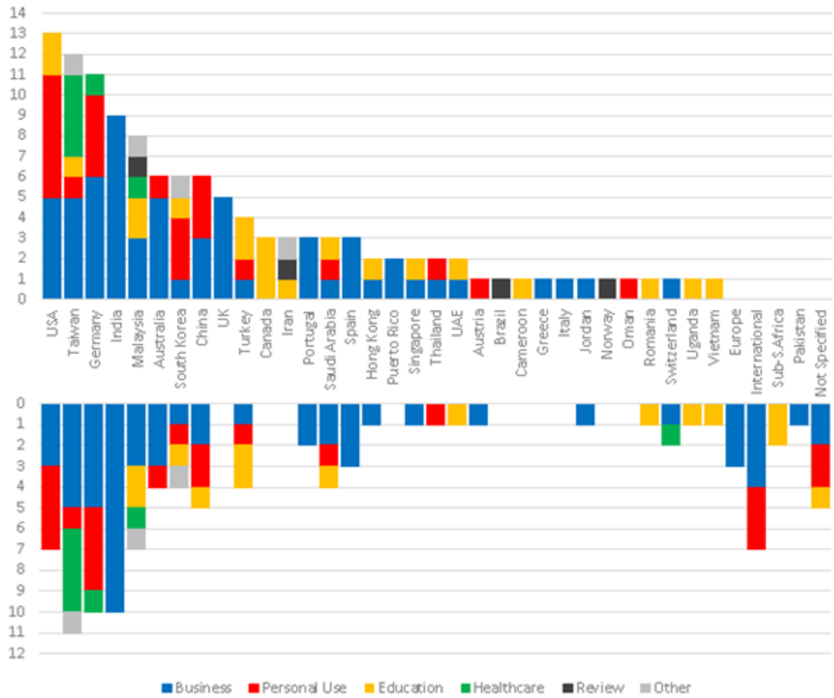

Figure 3: (a) Article count per author affiliation country. (b) Article count per survey country

Annual article counts of cloud studies employing SEM from 2009 to first half of 2018 are given in Figure 4.

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.

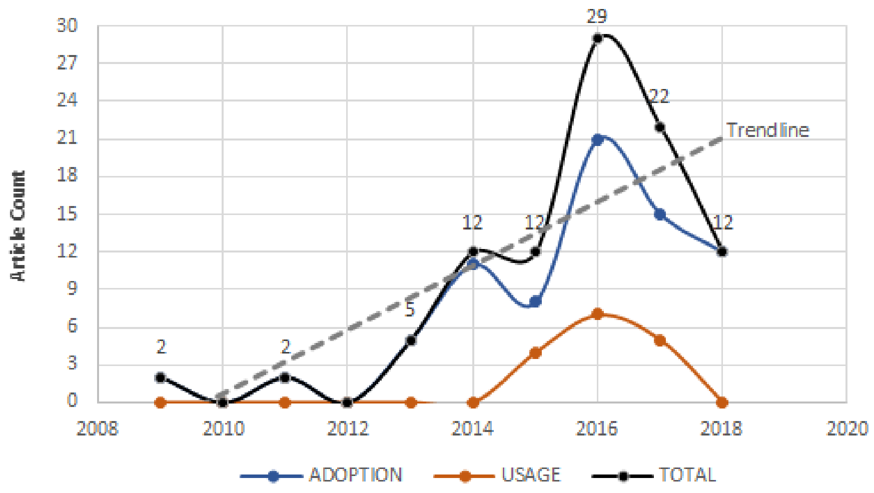

Figure 4: Annual article count

Article type count, study domains and the purposes of the articles for each venue / publisher can be seen in Figure 5.

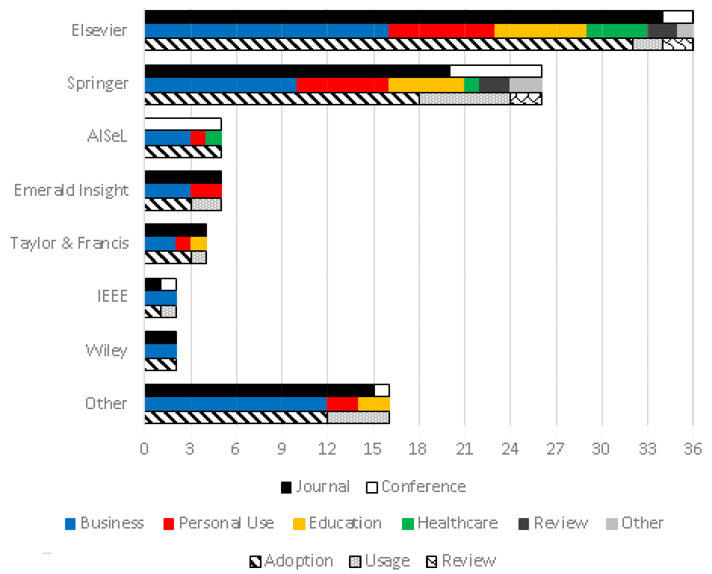

Figure 5: Annual article count per publish venue, study domain and purpose

Top twenty-five influential articles in terms of average annual citation count are given in Table 1.

Table 1: Most influential articles in terms of average annual citation

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

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. 76 of the 92 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 2.

Table 2: Annual article count per study domain and purpose

		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**		

Four main study domains are found in the cloud computing - SEM studies in this review, namely *business*, *personal use*, *education*, and *healthcare* domains. 50 of the primary studies focus on business and organisational 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 healthcare 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 6, whereas annual article counts from 2009 to first half of 2018 with regards to study domains is given in Figure 7.

All of the primary studies use a survey or questionnaire designed for the study in order to collect data from the target audience. Articles and the country of survey sample are given in Figure 3b. 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. Survey participant numbers of reviewed studies is plotted in Figure 8.

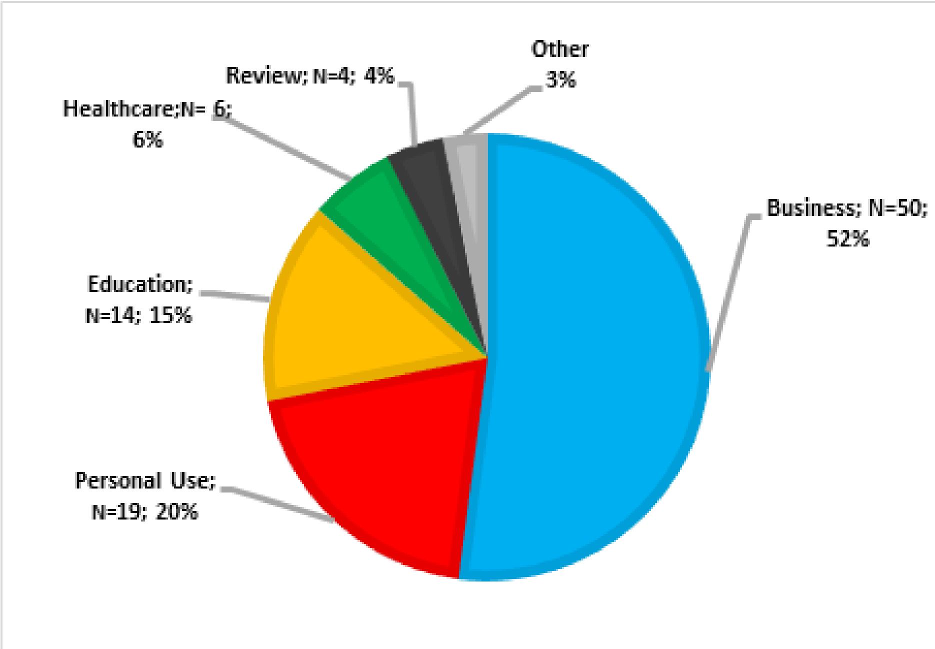

Figure 6: Study domains where cloud computing - SEM studies are conducted

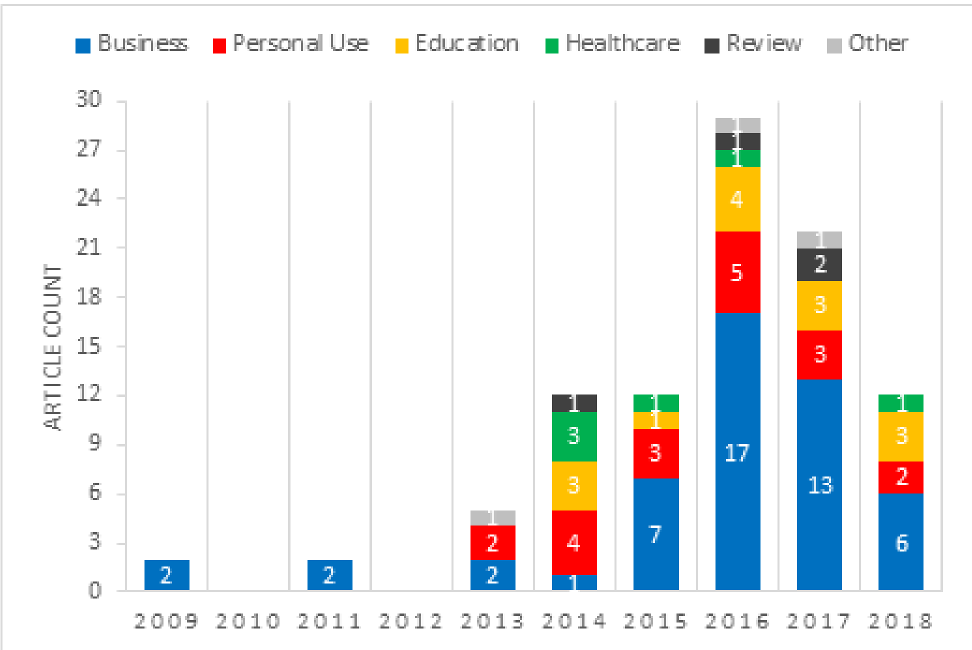

Figure 7: Annual article count per study domain

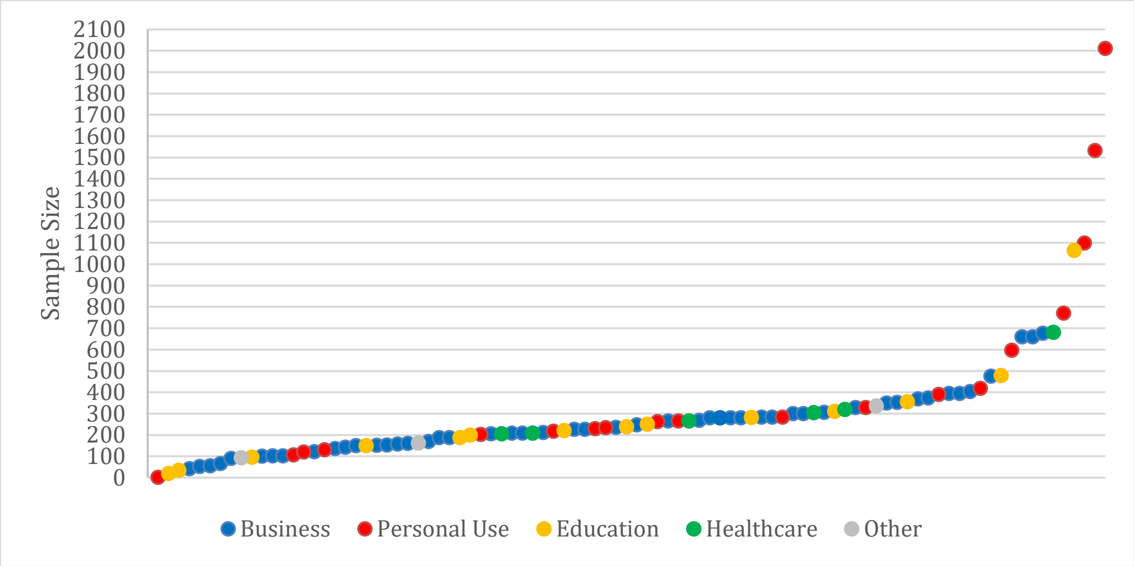

Figure 8: Sample size of studies and domains of each study

Numbers of studies with regards to their sample population can be seen in Figure 9.

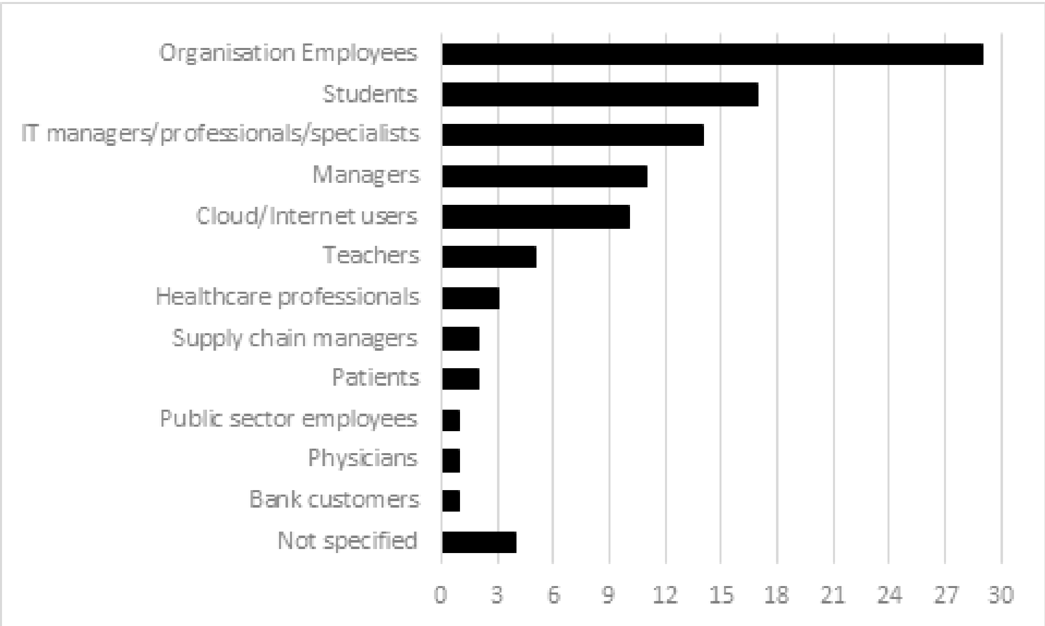

Figure 9: Characteristics of study sample populations

Cloud usage studies employ several different behaviour theories when they base their models on previous frameworks. Breakdown of all technology acceptance and behaviour theories in all articles is given in Table 3. Constructing hybrid models that are based on several theories and frameworks is a common approach in the literature. Frequencies of the theory combinations can be seen in Figure 10.

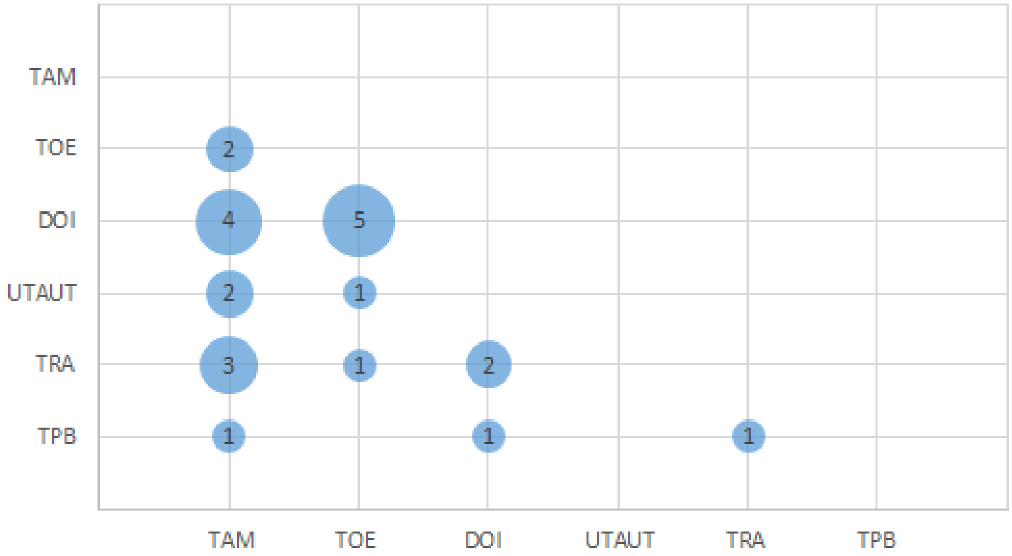

Figure 10: Frequency of theories used together

SEM technique requires a conceptual prior model defined by researches in order 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. 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 list of most commonly suggested causal factors and their acceptance and rejection percentages can be seen in Table 4.

Table 3: Theories and articles in which they are used

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]

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)
- Sample limitations (39 studies)
- Geographic location limitations (35 studies)
- Industry limitations (20 studies)
- Time frame limitations (19 studies)
- Cloud service type limitations (12 studies)

Table 4: Most commonly used constructs and factors

Suggested Causal Factor	**Occurrence**		**Acceptance**	**Rejection**	**Acceptance**
	Count	**Percentage**	**Count**	**Count**	**Percentage**
Security & Privacy	32	34.78	27	5	84.38
Costs	26	28.26	19	7	73.08
Ease of Use & 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 & Skills	10	10.87	6	4	60.00
Benefits	9	9.78	8	1	88.89

With the review of previous cloud computing - SEM studies, Q3 and Q4 from the main research questions are answered. The current state of literature is analysed in details; and as 92 primary studies are found to have used SEM for cloud adoption models with meaningful results, it can be said that it is an appropriate method for cloud adoption studies.

2.2. Cloud Computing and Software Development

Cloud technologies to be used in software development activities are mainly of interest for industry. However, there is a limited number of academic research conducted on the subject. The previous research on cloud technologies in software development did not aim to assess the adoption and use intention by individuals and communities. Studies in earlier stages of technology focused on the concept, challenges, and future of cloud; and the recent studies focus on specific cloud-based solutions to different issues in software development.

Table 5: Most commonly used dependent variables

Conceptual Dependent Variable	Occurrence	
	Count	**Percentage**
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 Behaviour	3	3.26
Firms Operational Performance	3	3.26
Behavioural Outcome	2	2.17
Enterprise Usage Intention	2	2.17
Loyalty	2	2.17
Resistance to Use	2	2.17

The early opinions and ideas of researchers on using cloud in software development can be traced back to before 2010, around the time cloud studies were gaining traction in academia in general. Cloud technologies were suggested to be revolutionary in this area, completely shifting the software development paradigm. Weinhardt et al. [10] say that the future direction of cloud technologies suggest a way to employ ready-to-use application components on cloud to develop software easily. In his editorial column, Erdogmus [11] makes a point against the idea that cloud computing will remove the need to write a single line of code and testing for software development. Dillon et al. [12] in their paper about the issues and challenges of cloud computing suggest that the interoperability of PaaS services was not entirely functional yet for end users to develop software on cloud.

Even though it is seen over time that cloud technologies did not revolutionarily change how software is developed, they have become valid (and in some cases, better) alternatives to traditional local solutions. Al-Rousan [13] in his 2015 paper examines the current challenges in global software development (GSD) and suggests cloud-based solutions. It is also possible to find studies that focus on further challenges of cloud computing itself. Almorsy et al. [14] investigated one of the biggest concerns about cloud: security. Regarding software development on cloud, they mention secure software development lifecycle (SDLC) which is a security methodology for developers and how the methodology can be improved for cloud-based development. They suggest to avoid hardcoded security measures by supporting adaptive security.

Recent studies focus on specific cloud-based solutions instead of general ideas on using cloud for software development. Malik and Singh [15] conducted a study on using several environments for software testing and cloud was one of the possible considerations. They suggest that Living Models approach can be used to benefit from the adaptive capabilities of cloud. Cloud-based software testing is a concept that has been having some research interest for a longer time period with different studies like the study by Candea et al. [16] that suggests Automated Software Testing as a Service; or the study by Mittal et al. [17] that suggests cloud-based environments to be important for the future of software testing.

Li and Gu [18] focused their research on cloud-based databases because of the increasing popularity of big data applications which require access to large databases. In their study, Li and Gu [18] suggest a hybrid database architecture which is cloud-based and allows simultaneous access to the database from different systems. Teixeira and Karsten [19] released their release management study on OpenStack environment which is a cloud-based software ecosystem that aims to improve release management by ensuring software is released early, often, and on time.

3. METHODOLOGY

3.1. Technology Adoption Theories

There are suggested models and theories that can be used when studying adoption and use of a technology by individual users or business organisations. In the conceptual models of the adoption studies, the factors and the constructs 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 [20].

Theories, frameworks, and models that can be used in designing new technology adoption models can be grouped under these categories [21]:

User acceptance theories: These theories focus on the perceptions and behaviours of employers and aim to explain their intentions rationally. Examples: Theory of Reasoned Action (TRA) [22], Theory of Planned Behaviour (TPB) [23], Technology Acceptance Model (TAM) [24][25][26], Motivation Model [27], Unified Theory of Acceptance and Use of Technology (UTAUT) [28].

Diffusion theories: These theories focus on the use of technology within an organisational context while taking environmental factors into consideration. Examples: Diffusion of Innovation Theory (DOI) [29], Technology Lifecycle Theory [29][30].

Decision making theories: These theories focus on the management policies and decisions. Examples: Rational Choice Theory, Game Theory, Risk Management, Change Management, Media Richness Theory.

Personality theories: These theories focus on cognitive interest of individuals. Examples: Technology Lifecycle Theory [29][30], Social Cognitive Theory (SCT) [31].

Organisation structure theories: These theories focus on organisational strategies. Examples: Disruptive Technology Theory [32], Creative Destruction Theory [33].

Technology adoption studies might design hybrid models that are a combination of several theories. The theories might be fully or partially employed with the addition of novel factors. In this thesis, such a hybrid model is suggested. The model is based on two existing theories as well as the novel approach of this thesis to the cloud acceptance model for software development activities. Technology Acceptance Model (TAM) and Technology-Organisation-Environment framework (TOE) are chosen as foundations of the hybrid model. TAM is selected because it focuses on personal perceptions of individual users of the technology and measures how their perceptions of the technology might affect their behavioural intention. TOE suggests a framework for the technology adoption models at the organisational level, taking factors such as management support or competitive pressure into account.

3.1.1. Technology Acceptance Model (TAM)

TAM is first suggested by Davis [24]. In his research, Davis [24] claimed that adoption of a new technology or an innovation is affected by users' perception of usefulness and ease of use of the innovation. He developed the first TAM model based on Theory of Reasoned Action (TRA) [22]. TRA is not a theory specifically developed to deal with technological innovations but in general it aims to find the effect of individuals' attitude on their behaviours. After the initial TAM model, further developments have been made over time, which resulted in TAM2 by Venkatesh and Davis [25] and TAM3 by Venkatesh and Bala [26]. Most recent TAM3 model consists of perceived usefulness and perceived ease of use with other factors that affect them as well as two variables with moderating effects on other pairwise relations in the model. Venkatesh and Bala [26] suggest that subjective norm, image, job relevance, output quality, and result demonstrability are the determinants of perceived usefulness. Whereas the effects on perceived ease of use is built on anchoring and adjustment framing of human decision making; and it is hypothesised that computer self-efficacy, perceptions of external control, computer anxiety, computer playfulness, perceived enjoyment, and objective usability have effects on perception of the ease of use. The overall structure of TAM3 can be seen in Figure 11. Factors that are taken from the determinants of TAM model to be used in this study are defined in the Initial Conceptual Model section together with the corresponding hypotheses.

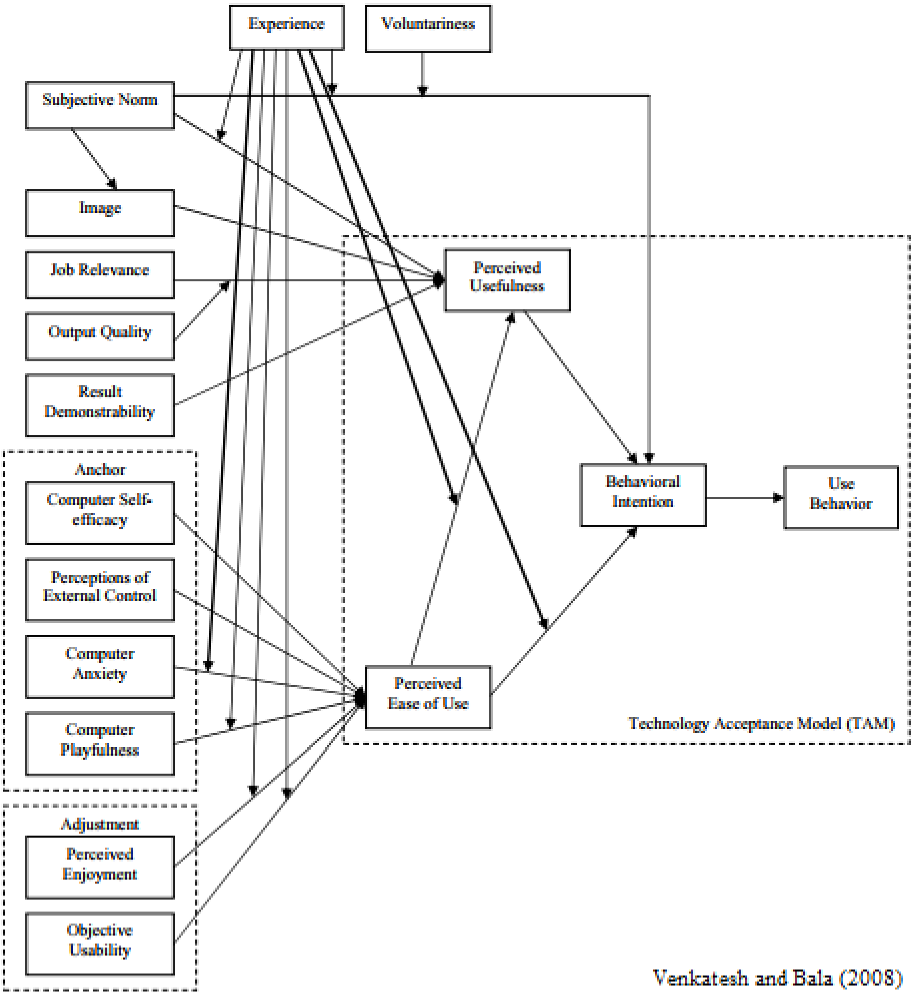

Figure 11: TAM3 structure and variables

3.1.2. Technology-Organisation-Environment (TOE)

TOE is a framework for models that aim to explain adoption and use of technological innovations in a business environment [34]. It is a framework based on three main elements, namely technological context, organisational context, and environmental context [35].

The variables selected under each element vary between studies. Depending on the cultural background of the organisation, the user base (i.e. employers in the organisation who will experience the technological innovation), and characteristics of the technology in question; the appropriate model is designed by researchers. In the broadest sense, the variables commonly used in technological, organisational, and environmental contexts can be listed as:

Technological context: Relative advantage, complexity, compatibility, cost, safety and security concerns

Organisational context: Top management support, training & education, benefits, organisational readiness

Environmental context: External support, trading partner support, competitive pressure

Technological, organisational, and environmental factors that are hypothesised to affect intention to use cloud in software development activities in this study are explained in the Initial Conceptual Model section.

3.2. Personal-Organisation-Project (POP)

Personal-Organisation-Project (POP) structure in the model is the novel suggestion of this study. While combining TAM and TOE factors to obtain a hybrid model that explains change in technology use intention better than models solely based on those theories, it is hypothesised that integrating a set of factors that measure the current state of the people, their organisation, and the software project they are currently working on will consider several aspects of the technology use that are not measured by TAM or Toe and this will improve the results of the model. The factors in the POP structure are: personal cloud use, organisation size, number of licensed software, project size, project budget, and project team size. These factors and their hypothesised effects on intention to use cloud in software development activities are explained in detail in the Initial Conceptual Model section.

3.3. Initial Conceptual Model (TAM-TOE-POP Hybrid)

A hybrid technology adoption model is developed with the aim of explaining developers' intention to use cloud in software development activities. The factors that are taken from previous TAM studies and adapted to the cloud computing use for professional purposes are perceived usefulness, perceived ease of use, computer self-efficacy, computer anxiety, subjective norm, image, job relevance, output quality, and results demonstrability. The factors that are selected from TOE framework to be used in this study are relative advantage, complexity, top management support, training & education, and external support. The factors that are based on the characteristics of people, project and organisation that are suggested to be in the model are project size (in KLOC), project budget, project team size, organisation size, number of licensed software, and personal cloud use (in non-professional daily life). A summary of factors with their source theories is given in Table 6.

Another novel suggestion of this study is to improve the technology use model by integrating actual current use and perceived suitability as factors that are linked to intention to use. This study suggests that if users are already using cloud technologies for some software development activities, they are more likely to have a more concrete idea about the suitability of cloud for other software development activities, and if they find cloud computing suitable to their projects, they will have higher intention to use it. With these relationships in mind, a three-piece structure of "actual use – perceived suitability – intention to use" is suggested to replace the "intention to use" factor of technology adoption models.

The initial hypotheses (IH) about pairwise relations of variables in the model are explained below. These initial hypotheses are revised and updated in Section 4.2 using exploratory factor analysis on the collected data. The revised final versions of the hypotheses are used in further statistical analyses.

Perceived Usefulness: Usefulness of a new technology has a direct effect on the intention to use that technology. It is predicted that users' perception of usefulness will increase their intention to adopt and use.

IH1: "Perceived usefulness will have a positive direct effect on intention to use cloud in software development."

Table 6: Variables in the conceptual model

TAM	**TOE**	**POP**
Perceived usefulness	Top management support	Personal cloud use
Perceived ease of use	Training & education	Project size
Results demonstrability	Complexity	Project budget
Image	Relative advantage	Project team size
Subjective norm	External support	Organisation size
Computer self-efficacy		Number of licensed software
Computer anxiety		
Top management support		
Training & education		

Perceived Ease of Use: It is predicted that perceived ease of use of a new technology by individual users is especially important in the case of a new technology adoption. It might not be an as prevalent effect on continuous usage studies as it is here, but for a new technology perceived ease of use has an effect on the use intention. It is also predicted that when users perceive a new technology easy to use, they are inclined to feel it is also useful.

IH2a: "Perceived ease of use will have a positive direct effect on intention to use cloud in software development."

IH2b: "Perceived ease of use will have a positive direct effect on perceived usefulness."

Results Demonstrability: Results demonstrability is defined as "tangibility of the results of using the innovation" [36]. When the results of using a new technology over other alternatives are clear, it is predicted that users will believe the usefulness of the technology.

IH3: "Results demonstrability will have a positive direct effect on perceived usefulness."

Image: Image is defined as "*the degree to which use of an innovation is perceived to enhance one's status in one's social system*" [36]. It is predicted that developers' perception of image will increase their perception of usefulness of an innovation.

IH4: "Image will have a positive direct effect on perceived usefulness."

Subjective Norm: Subjective norm is the effect of users' environments on them that pushes them towards or away from a new technology. It is defined as "*the perceived social pressure to perform or not to perform the behaviour*" [23]. It is predicted that the users' subjective norm will improve their perception of usefulness of an innovation.

IH5: "Subjective norm will have a positive direct effect on perceived usefulness."

Job Relevance: Job relevance is employers' perception of a new innovation with regards to their own current job. It is predicted that if they find the new technology relevant to the tasks they complete at work, they are more likely to find the technology useful for their job.

IH6: "Job relevance will have a positive direct effect on perceived usefulness."

Output Quality: Output quality is the degree to which individuals believe that the new technology performs their tasks well [25]. It is predicted that when users find the output of using a particular technology to be of higher quality, they tend to find that technology useful compared to other alternatives.

IH7: "Output quality will have a positive direct effect on perceived usefulness."

Computer Self-Efficacy: Computer self-efficacy is users' belief on their own ability to perform a specific task using the computer [31][37]. It is predicted that if users feel more confident to use computers to complete the tasks, they will find the technology easier to use.

IH8: "Computer self-efficacy will have a positive direct effect on perceived ease of use."

Computer Anxiety: Computer anxiety, in a sense, is the negative version of computer self-efficacy. It is described as individuals' apprehension, or even fear, when they are faced with the possibility of using computers [38]. It is predicted that when they feel anxiety about using computers, they will find new technologies harder to use over alternatives they are already familiar with.

IH9: "Computer anxiety will have a negative direct effect on perceived ease of use."

Top Management Support: Top management support is indicated by both users' perception of the support they have from the management on the use of a new technology and the training and education that will be provided by the management. It is predicted that when the management supports the adoption of a new technology and they provide training in a professional environment, users will be more likely to adopt new technologies for their work.

IH10: "Top management support will have a positive direct effect on intention to use cloud in software development."

Training & Education: Training and education are provided to employers by the management in a professional business environment. It can be about a new technology being adopted, a change in the work system, or any other external improvement that employers of the organisations are desired to have. In the case of adopting a new technology; it is predicted that if employers are provided with training and education specifically related to the technology, they are more likely to have intentions to accept innovations.

IH11: "Training & education will have a positive direct effect on intention to use cloud in software development."

Complexity: Complexity is a characteristic of the technology. Apart from the extreme cases of specific demographics of users that like the idea of a challenge, perceived complexity of a new technology is predicted to decrease users' intention to use the technology over other, simpler alternatives.

IH12: "Complexity will have a negative direct effect on intention to use cloud in software development."

Relative Advantage: When a new technology is to be adopted, whether for personal use or in a business environment, it has to have some advantage over alternatives to convince adopters. Relative advantage is users' belief of the advantage the new technology has over previous alternatives and this belief is predicted to have a positive relationship with intention to adopt.

IH13: "Relative advantage will have a positive direct effect on intention to use cloud in software development."

External Support: External support is measured as the support from government with laws and regulations that is perceived by developers. It is predicted that they will be more inclined to use cloud technologies if they perceive the existence of this support.

IH14: "External support will have a positive direct effect on intention to use cloud in software development."

Personal Cloud Use: Personal cloud use aims to measure the familiarity and experience of individuals with cloud based technologies in their non-professional daily lives. It is predicted that if the users are already comfortable with using cloud services, they might perceive such services more suitable to their job and have higher intention to use cloud on software development.

IH15: "Personal cloud use will have a positive direct effect on intention to use cloud in software development."

Project Size: Project size is measured in KLOC. Even though in reality it is not a measurement that is enough by itself to explain the size of software projects, it is a base estimation for how large the software project can get. It is predicted that as the project size (hence the complexity) increases, developers will find cloud alternatives less suitable be less inclined to move their work to cloud environments.

IH16: "Project size will have a negative direct effect on intention to use cloud in software development."

Project Budget: Project budget is the budget allocated to the project by top management. It is mainly based on the size and scope of the project and it can be affected by numerous factors such as project size, project duration, project team, importance and urgency of the project, or the project contractor. As cloud services are usually advertised as cheaper options to local solutions with the freedom of pay-per-use cases, it is predicted that cloud technologies will be more suitable to projects with stricter budget. Also the developers working in these projects are predicted to have higher intention to use cloud in software development.

IH17a: "Project budget will have a negative direct effect on intention to use cloud in software development."

IH17b: "Project budget will have a negative direct effect on perceived suitability of cloud in software development."

Project Team Size: Project team size is the number of team members for the particular project on which respondent developers are currently working. As moving software development efforts to cloud environments helps with the communication within the team as well as documentation processes, it is predicted that projects with larger team sizes will be more likely to want to adopt cloud technologies as these technologies will be more suitable to such projects.

IH18a: "Project team size will have a positive direct effect on intention to use cloud in software development."

IH18b: "Project team size will have a positive direct effect on perceived suitability of cloud in software development."

Organisation Size: Organisation size is the number of employers within the organisation. This does not necessarily affect the size and scope of the projects directly as a relatively small organisation might be undertaking one big project or a very large organisation might be simultaneously working on many projects with smaller teams. However, overall size of the companies will still have an effect on the decision of cloud usage on the management level at least. It is predicted that larger organisations will have higher intention to use cloud technologies as these technologies help with management, coordination, communication, and accessibility in the projects. However, conversely, it is predicted that the size of the organisations will negatively affect the top management support that developers and employers individually perceive as well as the training and education opportunities.

IH19a: "Organisation size will have a positive direct effect on intention to use cloud in software development."

IH19b: "Organisation size will have negative direct effect on top management support."

IH19c: "Organisation size will have negative direct effect on training & education."

Number of Licensed Software: Number of licensed software is measured by giving 12 categories of software and respondents are asked to select the ones they have officially purchased. The given categories are requirements tools, design tools, test tools, maintenance tools, software engineering process tools, quality tools, configuration management tools, project management tools, operating systems, office applications, integrated development environments, and database management systems.

IH20: "Number of licensed software will have a negative direct effect on intention to use cloud in software development."

Actual Use – Perceived Suitability – Intention to Use: It is predicted that if users are already using cloud technologies for some software development activities, they are more likely to have a more concrete idea about the suitability of cloud for other software development activities, and if they find cloud computing suitable to their projects, they will have higher intention to use it. The perceived suitability based on actual use might be positive or negative depending on their personal experience, for the null hypotheses at this point it is predicted that actual use will positively affect perceived suitability.

IH21: "Actual use of cloud in software development will have a positive direct effect on perceived suitability of cloud for software development."

IH22: "Perceived suitability of cloud for software development will have a positive direct effect on intention to use cloud in software development."

To reflect all the hypotheses on pairwise relations, the full hybrid model is designed as given in Figure 12. Correlations between exogenous variables and error terms are not shown to keep the figure legible.

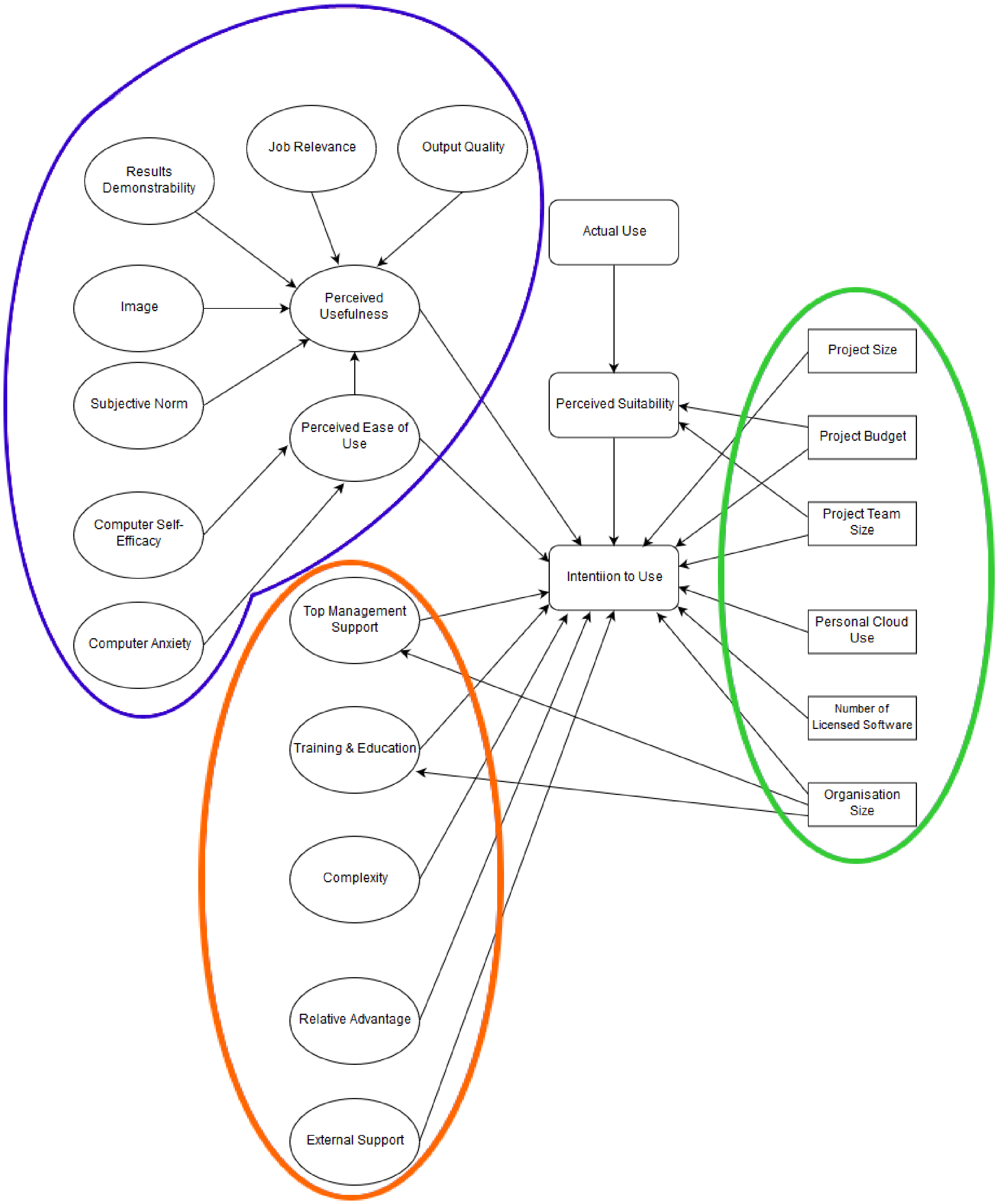

Figure 12: Initial conceptual mode

3.4. Questionnaire

The structure and the framework of the conceptual model to explain the behavioural intention to use cloud computing in software development activities is based on the literature. Previous technology adoption and use studies validated their conceptual models based on several technology adoption and behavioural theories, the questionnaire used to collect data in this study is also initially based on factors and questions used in the previous studies. Items used in the questionnaire with respect to their sources are given in Table 7. The questionnaire items for factors based on TAM and TOE theories are on a 1-5 Likert scale. Items that measure the POP structure of the model are either multiple choice with discrete categories or open questions. The full questionnaire used in this study is given in Appendix 2.

Table 7: Questionnaire items and sources

Item	**Source**	**Item**	**Source**
PU1	Venkatesh and Bala [26]	CLX2	Oliveira et al. [39]
PU2	Venkatesh and Bala [26]	TMS1	Oliveira et al. [39]
PEOU1	Venkatesh and Bala [26]	TMS2	Lian et al. [40]
PEOU2	Venkatesh and Bala [26]	TE1	Gangwar et al. [41]
CSE1	Venkatesh and Bala [26]	EXSP1	Oliveira et al. [39]
CAX1	Venkatesh and Bala [26]	EXSP2	Lian et al. [40]
SN1	Venkatesh and Bala [26]	INT	Çoban et al. [42]
IMG1	Venkatesh and Bala [26]	SUI	Çoban et al. [42]
REL1	Venkatesh and Bala [26]	ACT	Çoban et al. [42]
OUT1	Venkatesh and Bala [26]	PRSZ	Garousi et al. [3]
RES1	Venkatesh and Bala [26]	PRBG	Garousi et al. [3]
RES2	Venkatesh and Bala [26]	PRTS	Garousi et al. [3]
RES3	Venkatesh and Bala [26]	PCLU	Garousi et al. [3]
RAD1	Oliveira et al. [39]	NOLS	Garousi et al. [3]
CLX1	Gangwar et al. [41]	ORSZ	Garousi et al. [3]

Questions that were used in previous TAM and TOE studies are examined and the ones that are found relevant to cloud technologies are selected. Questions that focus on software development activities are based on previous software development demographics studies. Questions for the novel additions to the model are self-developed. An extensive questionnaire consisting of these different groups of questions is prepared to conduct the study with software developers, project managers, and senior executives in organisations. The questionnaire is designed together with the expert scholars working in the domain of software engineering and cloud computing. The pilot questionnaire was applied to participants and academics in the software industry. According to feedbacks and recommendations, the questionnaire was revised and finalised to apply to the study sample.

3.5. Structural Equation Modelling (SEM)

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 an *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 indicators. 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 [43]. 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 [44].

SEM started to appear in the literature in the 70s and it gained more interest in the 80s. The observation and formulation of complex problems in social sciences with factors that are not directly measurable 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 70s 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 [45].

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 [46]. Path analysis models are also based on regression analyses and correlation coefficients, and are used to test more complex relations between observed variables [47]. 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 in order to define constructs using summed scores of individual responses to a set of correlated items [48]. The confirmatory factor analysis (CFA) technique as it is used today was fully developed later on [49]. 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 modelling 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. [50] employed SEM and Artificial Neural Networks (ANN) for an adoption study on mobile learning technologies. Raut et al. [51] developed a three-stage hybrid model which included SEM, ANN, and Interpretive Structural Modelling (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 or unobserved 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 as well as the characteristics of the independent variable used in models (i.e. it assumes all independent variables are measured without error), SEM can be used to build and test complex models in many domains like social sciences, technology, or information systems. 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 [43]. Davis [24] investigated the use of SEM particularly in information systems (IS) domain by employing SEM as the statistical tool to analyse the data in his information systems study, which was followed by other similar and replication studies such as [52], [53], and [54]. Although the SLR part of this thesis focuses on the use of SEM in cloud studies and the primary study of this thesis employs SEM to build a cloud adoption model, 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 [55]. 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, analysing formative and reflective constructs, number of interaction terms, and mediated models [56]. Having the opportunity to work with relatively smaller sample sizes and non-normal cases are the strong advantages of the technique.

A SEM model consists of two parts, a measurement model and a structural model. Measurement model is the part of the SEM model that uses observed variables (indicators) to explain changes in unobserved (latent) variables. In the measurement model, the directed arcs are from the latent variable to all the indicators of that variable in the sense that indicators do not cause the latent variable but the latent variable manifests itself through the observed indicators in real life. Questionnaire items specifically designed for each latent variable in the model are included as indicators and the variable itself is the latent factor in the measurement model of this study. Structural model is the part of the SEM model researchers want the method to calculate, it is the relationships between latent variables that normally would not be possible to calculate with simple regression without the inclusion of measurement model. SEM aims to find significant relationships between latent variables by the use of observed, measurable indicators.

4. ANALYSES AND RESULTS

4.1. Data Collection and Demographics

Researchers of this study reached out to 30 different organisations in various sectors that develop software as either their primary or secondary business activity. The questionnaires were personally administered with software developers working in active software projects in the 30 organisations. This method is chosen over online surveys because of the control it provides over the respondents' care and attention to the questionnaire as well as the possibility of directly assisting the respondents' in case they have a problem regarding the questionnaire. 191 unique respondents have answered the questionnaire from 30 organisations, with respect to 84 different software development projects. This gives 268 different observations because developers affiliated with multiple projects simultaneously responded the questionnaire for all different projects separately. Demographics of the individual respondents as well as the projects they work on and the organisations participated in the questionnaire is given in Table 8, Table 9, and Table 10, respectively.

Table 8: Personal demographics

Unique respondents (N = 191)					
Gender	***n***	***%***	***Education***	***n***	***%***
Female	32	16.8	High school or pre-graduate	4	2.7
Male	159	83.2	Graduate	121	63.3
			MSc	56	29.3
			PhD	9	4.7
Age	***n***	***%***	***Work Experience***	***n***	***%***
Less than 18	0	0	Less than a year	27	14.1
18-25	20	10.4	1 - 5 years	43	22.5
26-33	86	45.1	6 - 10 years	56	29.3
34-41	58	30.4	11 - 20 years	54	28.3
42 and older	27	14.1	More than 20 years	11	5.8

Table 9: Project characteristics

Project (N = 84)					
Project Size	***n***	***%***	***Contractor***	***n***	***%***
<10 KLOC	4	4.8	Sole contractor	70	83.3
10-99 KLOC	13	15.5	Consortium	14	16.7
100-1000 KLOC	17	20.2	***Deployment Model***	***n***	***%***
>1000 KLOC	10	11.9	Own physical server	44	52.4
No estimation	40	47.6	Rented physical server	11	13.1
Project budget	***n***	***%***	Rented virtual server	20	23.8
< $50,000	20	23.8	Own virtual server	34	40.5
$50,000 - $100,000	7	8.3	***Software Process Model***	***n***	***%***
$100,000 - $500,000	17	20.2	Agile	64	76.2
> $500,000	37	44.1	Incremental	24	28.6
Not disclosed	3	3.6	Waterfall	14	16.7
Project Team Size	***n***	***%***	***Programming Language***	***n***	***%***
1 – 3	24	28.6	Java	51	60.7
4 – 7	38	45.2	JavaScript	49	58.3
8 – 15	12	14.3	PHP / ASP / JSP	29	34.5
16 - 35	10	11.9	C++	18	21.4
Financial Sources	***n***	***%***	iOS / Swift	18	21.4
100% domestic	70	83.3	C#	16	19
Mostly domestic	5	6	Python	16	19
Mostly international	6	7.1	Objective-C	11	13.1
100% international	3	3.6	Other	14	16.7

After cleaning the data, 272 of the responses are found valid for the analyses. The low number of eliminated responses from the analyses may be explained by the use of personally administered questionnaire instead of online survey forms.

Table 12 (cont.): Project characteristics

Project (N = 84) (continued)		
Geographic Location	***n***	***%***
Single office	63	75
Two offices in the same city	11	13.1
More than two offices in the same city	1	1.2
Multiple offices in two cities	6	7.1
Multiple offices in more than two cities	3	3.6
Mobility	***n***	***%***
No mobility	43	51.2
Less than half of the team partially mobile	22	26.1
Less than half of the team mostly mobile	1	1.2
Half of the team partially mobile	13	15.5
More than half of the team partially mobile	1	1.2
More than half of the team mostly mobile	3	3.6
Almost entire team partially mobile	1	1.2
Developed Software Type	***n***	***%***
Safety-critical and life-critical systems	25	29.8
Business applications	32	38.1
Science/Engineering applications	8	9.5
System software	11	13.1
Web applications	52	61.9
Mobile applications	30	35.7

4.2. Consistency, Validity, and Exploratory Factor Analysis (EFA)

The part of the data collected to measure the factors based on TAM and TOE are first checked for internal consistency, then are taken through exploratory factor analyses to ensure the item groupings are as intended and the questions do not load on unplanned factors. Cronbach’s alpha for TAM items is calculated as 0.803, and for TOE items is calculated as 0.722. Both of the values are above the desired threshold of 0.7 [57], and thus the study may proceed to exploratory factor analysis for validation.

Table 10: Organisation characteristics

Organisation (N = 30)					
Organisation Size	***n***	***%***	***Number of Projects***	***n***	***%***
1 - 9	8	26.7	1 - 10	18	60
10 - 49	9	30	11 - 25	8	26.7
50 - 99	0	0	26 - 75	2	6.7
100 - 499	7	23.3	76 - 200	0	0
500 +	6	20	200 +	1	3.3
Annual Business Volume	***n***	***%***	Not reported	1	3.3
< $100,000	2	6.7	***Organisation Sector***	***n***	***%***
$100,000 - $500,000	10	33.3	Banking / Finance	7	23.3
> $500,000	15	50	Public Sector	14	46.7
Not disclosed	3	10	Military and Defence	11	36.7
Organisation Age	***n***	***%***	Engineering / Manufacturing	9	30
1 - 10	14	46.7	IT / Telecommunication	13	43.3
11 - 25	9	30	Insurance	3	10
26 +	7	23.3	Healthcare	7	23.3
			Management	7	23.3

Correlation matrix of items based on TOE, as well as descriptive statistics of these items, are given in Table 11. Similarly, correlation matrix and descriptive statistics for TAM items are available in Table 12. It can be seen that none of the correlations in either matrix falls outside the desired range of [-0.8, 0.8]. Other parameters for the items are KMO (Kaiser-Meyer-Olkin Measure of Sampling Adequacy) and the significance level of the Bartlett's Test of Sphericity. The absolute minimum for KMO values is 0.5 whereas the Bartlett’s Test is desired to be significant ($p<0.001$). KMO values for TAM and TOE items are 0.789 and 0.667, respectively. Both of the p-values are very close to 0.00. Thus, it can be commented that KMO values are above the desired threshold by a large margin and the tests are significant.

Exploratory factor analysis with Varimax rotation gives the groupings of items that are shown in Table 13 for TOE items and in Table 14 for TAM items. Based on this result, item groupings are revised and latent factors in the model are updated.

Table 11: Descriptive statistics and correlation matrix of TOE items

Items	Mean	Std. Dev.	RAD1	CLX1	CLX2	TMS1	TMS2	TE1	EXSP1	EXSP2
RAD1	3.734	0.826	1.000							
CLX1	2.609	1.199	-.064	1.000						
CLX2	2.024	0.803	-.118	.534	1.000					
TMS1	3.477	1.141	.076	-.353	-.260	1.000				
TMS2	3.482	1.216	.193	-.352	-.231	.738	1.000			
TE1	2.450	1.258	.185	-.172	-.099	.529	.609	1.000		
EXSP1	2.306	1.084	.060	-.246	-.072	.339	0.249	.199	1.000	
EXSP2	1.872	0.779	-.107	-.041	.077	-.014	.035	0.000	.396	1.000

According to the exploratory factor analysis, items that measure subjective norm and image, in fact, measure the same factor and there is no need to use two separate factors. Instead these two items can load on a single image factor. Similarly, output quality and job relevance do not measure two different factors, furthermore they load on the perceived usefulness factor. Items that measure output quality and job relevance are combined with the ones measuring perceived usefulness and they all load on the factor perceived usefulness. Items that measure computer self-efficacy and computer anxiety are found to measure the same variable, as they are in the opposite directions of each other, computer anxiety responses are reversed and then two variables are combined into one that is named technology competence in this study. Last revision to the model is to combine items that measure top management support and training & education to load on a single top management support factor. All these combinations and revisions sound logical with respect to existing definitions in literature. Subjective norm is defined as "*the perceived social pressure to perform or not to perform the behaviour*" [23] whereas image is "*the degree to which use of an innovation is perceived to enhance one's status in one's social system*" [36]. Similarly, output quality and job relevance are measured in the questionnaire in a way that is directly related to the measurement of perceived usefulness. Training & education is found to be directly relevant to top management support as the existence of this support is the main factor that motivates companies to arrange the educational activities.

Table 12: Descriptive statistics and correlation matrix of TAM items

Items	Mean	St. Dev.	PU1	PU2	PEOU1	PEOU2	SN1	IMG1	REL1	OUT1	RES1	RES2	RES3	CSE1	CAX1
PU1	3.74	0.9	1												
PU2	3.56	0.96	0.71	1											
PEOU1	3.65	0.82	0.38	0.28	1										
PEOU2	3.47	0.94	0.13	0.1	0.223	1									
SN1	2.42	0.91	0.18	0.19	0.175	-0.043	1								
IMG1	3.24	1.03	0.44	0.46	0.266	0.102	0.509	1							
REL1	3.81	0.97	0.3	0.25	0.026	-0.086	0.08	0.173	1						
OUT1	3.42	0.91	0.64	0.56	0.354	0.148	0.273	0.497	0.44	1					
RES1	3.8	0.69	0.38	0.39	0.453	0.183	0.107	0.246	0.28	0.655	1				
RES2	3.73	0.97	0.17	0.27	0.25	0.101	0.005	0.187	0.26	0.464	0.66	1			
RES3	3.74	0.85	0.17	0.14	0.29	0.103	-0.03	0.085	0.15	0.235	0.41	0.63	1		
CSE1	3.72	0.91	0.13	0.15	0.173	0.078	-0.01	0.198	0.23	0.236	0.28	0.49	0.48	1	
CAX1	4.29	0.71	0.23	0.27	0.246	0.049	0.092	0.179	0.13	0.315	0.42	0.48	0.32	0.36	1

Table 13: Rotated Component Matrix of TOE items

	Component			
	1	2	3	4
TMS2	.860			
TE1	.839			
TMS1	.798			
CLX2		.878		
CLX1		.839		
EXSP2			.855	
EXSP1			.750	
RAD1				.985

Table 14: Rotated Component Matrix of TAM items

	Component				
	1	2	3	4	5
PU1	.858				
PU2	.814				
OUT1	.737				
REL1	.549				
RES2		.888			
RES3		.827			
RES1		.710			
SN1			.914		
IMG1			.711		
PEOU2				.782	
PEOU1				.535	
CAX1_r					.823
CSE1					.823

4.3. Iterative Confirmatory SEM Analyses

The several different structural models which include the unobserved latent variables are then built upon this revised measurement model. Hypotheses about intention to use cloud in software development are based on this model and they are to be tested with the SEM analysis. Before building the final hybrid cloud adoption model and the behavioural hypotheses of this study, several sections of the model that are based on different theories from the literature are tested separately in an iterative manner.

4.3.1. TAM Model

TAM is a theory that aims to explain the behavioural intention to use an innovation or a new technology by the individual's perceptions about this technology and themselves. After the exploratory factor analysis in this study, the sub-section of the conceptual model that is based on TAM is found to be a five factor structure that affects the intention to use cloud in software development while also having other pairwise interactions between them. Perceived usefulness and perceived ease of use affect intention to use whereas results demonstrability and image affect perceived usefulness and computer self-efficacy affect perceived ease of use. According to TAM theory, perceived ease of use also has an effect on perceived usefulness. Graphical structure of TAM model is given in Figure 13. When the estimates for the model are calculated and validated using the collected data, it is found that it explains only 31.2% of the change in intention to use while also having overall goodness of fit values out of the desired range. CMIN/DF value for the model is found to be 4.316, which is desired to fall around 2 (smaller than 3 is acceptable) for a good fit. RMSEA value is found to be 0.111, which is desired to be as close to 0.06 as possible (possibly within the range of 0.004 – 0.007).

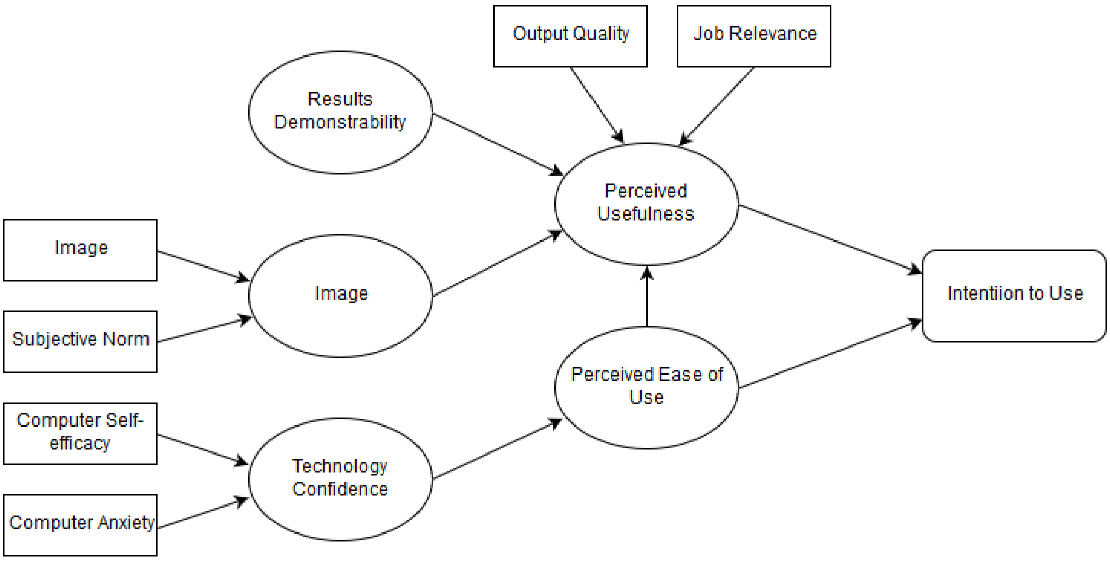

Figure 13: TAM section of the model

4.3.2. TOE Model

Another section of the hybrid model is rooted in the TOE framework. The TOE framework aims to explain behavioural intention to adopt or use a technology from a business perspective. The framework suggests to examine technological, organisational, and environmental factors together to understand the underlying effects of behavioural intention. In this study, four separate factors are found to measure the TOE perspective in the model which are top management support, complexity, relative advantage, and external support. The sub-section of the model based on TOE is given in Figure 14. When the model solely based on TOE is calculated with these three factors, it is seen that is has high goodness of fit values to the data (with parameters such as CMIN/DF = 1.533, p-value for chi-square = 0.064, RMSEA = 0.045). However, as it mainly focuses on organisational aspect, it explains only 35% of the change in intention to use cloud for software development.

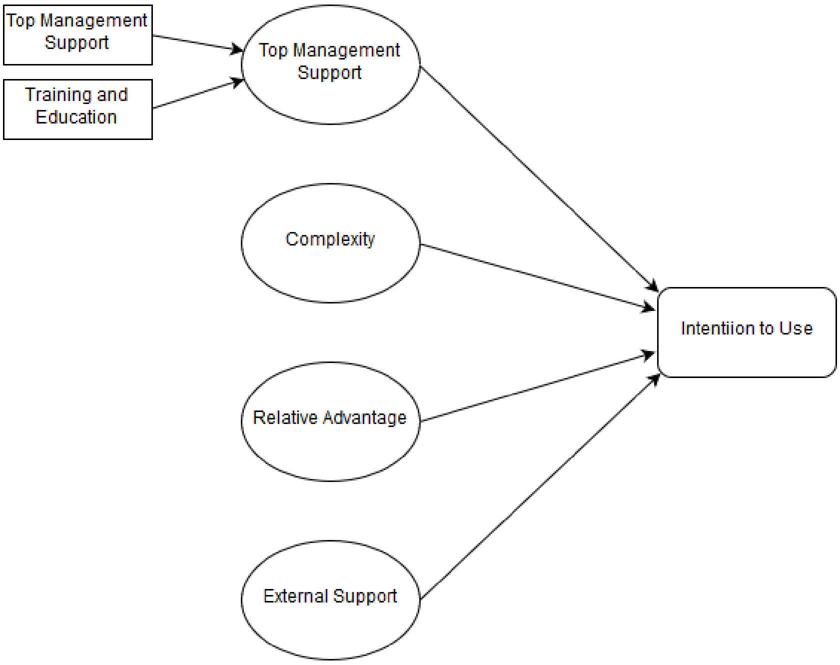

Figure 14: TOE section of the model

4.3.3. TAM-TOE Hybrid Model

In the next iteration, a hybrid model based on TAM and TOE is tested. In this model factors from both theories are assumed to keep their own inner structures and to have direct effects on intention to use cloud computing in software development without affecting each other. The hypothesised TAM-TOE hybrid model with the variables used in this study is built as in Figure 15. This structure is found to explain 39.8% of change in use intention while also having poor goodness of fit indices (CMIN/DF = 3.237, RMSEA = 0.092). Even though the indices are still not in the required levels, it can be seen that integrating TAM structure in TOE framework improves the model fit in the case of software development on cloud.

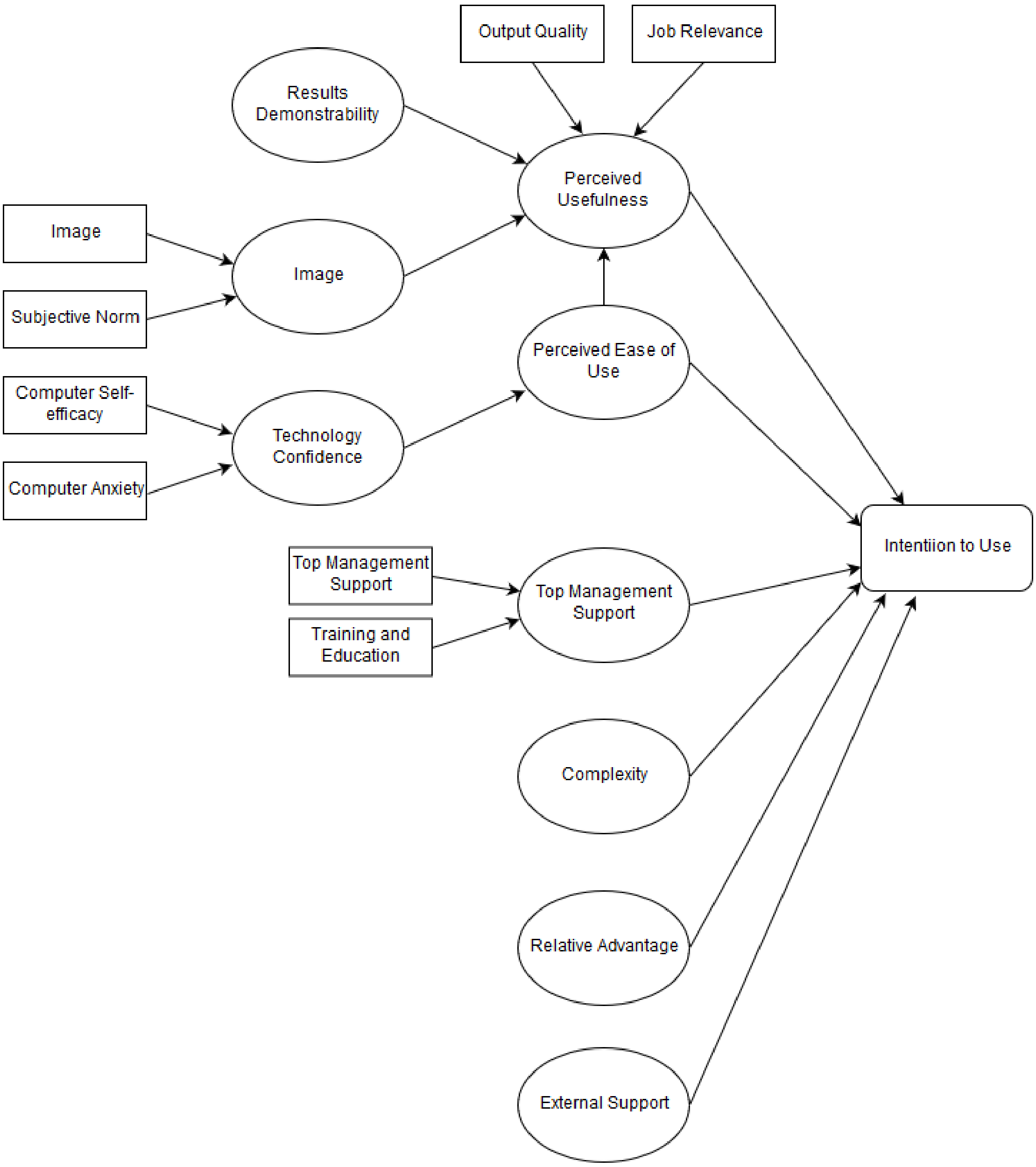

Figure 15: TAM and TOE hybrid model

4.3.4. TAM-TOE-POP Hybrid Model

At the final iteration of the confirmatory phase of the SEM analyses, the novel hybrid model based on TAM, TOE, and POP variables is built with the inclusion of perceived suitability and actual use of cloud in software development. This model is the revised version of the initial conceptual model after exploratory factor analysis is run using the questionnaire data. Several factors are combined into one as per the factor analysis results. The hypotheses that this model aims to test and validate are also revised. Hypotheses about the factors that are combined with others are removed and the ones about the new combinations of factors are updated. In the remaining part of this section, the revised conceptual model and hypotheses are explained. Based on the output of the conceptual model and results of the hypotheses tests, the study then enters the exploratory phase to improve the conceptual model to remove and add pairwise relations and correlations with the purpose of revealing a conceptual model that explains the intention to use cloud in software development better.

The revised hypotheses about pairwise relations of variables in the model are listed below. Updated and combined factors are defined with the revised hypotheses. For the variables with no changes to the initial hypotheses, only the hypothesis is listed.

Perceived Usefulness:

H1: "Perceived usefulness will have a positive direct effect on intention to use cloud in software development."

Perceived Ease of Use:

H2a: "Perceived ease of use will have a positive direct effect on intention to use cloud in software development."

H2b: "Perceived ease of use will have a positive direct effect on perceived usefulness."

Results Demonstrability:

H3: "Results demonstrability will have a positive direct effect on perceived usefulness."

Image: Image in this study is estimated with two indicators from the original TAM structure. As it is explained in the Methodology section of this thesis, image is enhancement degree of using a new technology on users' social status whereas subjective norm is the effect of users' environments on them that pushes them towards or away from a new technology. It is predicted that these social constructs will increase users' perception of usefulness of an innovation.

H4: "Image will have a positive direct effect on perceived usefulness."

Technology Confidence: Technology confidence is based on two different indicators, computer self-efficacy and computer anxiety. As these measure two opposite ends of behaviour, computer anxiety scores are reversed in calculations in this study and this way it is predicted that technology confidence will boost users' perception of usefulness.

H5: "Technology confidence will have a positive direct effect on perceived ease of use."

Top Management Support: Top management support is indicated by both users' perception of the support they have from the management on the use of a new technology and the training and education that will be provided by the management. It is predicted that when the management supports the adoption of a new technology and they provide training in a professional environment, users will be more likely to adopt new technologies for their work.

H6: "Top management support will have a positive direct effect on intention to use cloud in software development."

Complexity:

H7: "Complexity will have a negative direct effect on intention to use cloud in software development."

Relative Advantage:

H8: "Relative advantage will have a positive direct effect on intention to use cloud in software development."

External Support:

H9: "External support will have a positive direct effect on intention to use cloud in software development."

Personal Cloud Use:

H10: "Personal cloud use will have a positive direct effect on intention to use cloud in software development."

Project Size:

H11: "Project size will have a negative direct effect on intention to use cloud in software development."

Project Budget:

H12a: "Project budget will have a negative direct effect on intention to use cloud in software development."

H12b: "Project budget will have a negative direct effect on perceived suitability of cloud in software development."

Project Team Size:

H13a: "Project team size will have a positive direct effect on intention to use cloud in software development."

H13b: "Project team size will have a positive direct effect on perceived suitability of cloud in software development."

Organisation Size:

H14a: "Organisation size will have a positive direct effect on intention to use cloud in software development."

H14b: "Organisation size will have negative direct effect on top management support."

Number of Licensed Software:

H15: "Number of licensed software will have a negative direct effect on intention to use cloud in software development."

Actual Use – Perceived Suitability – Intention to Use:

H16: "Actual use of cloud in software development will have a positive direct effect on perceived suitability of cloud for software development."

H17: "Perceived suitability of cloud for software development will have a positive direct effect on intention to use cloud in software development."

To reflect the final hypotheses on pairwise relations, the full hybrid model is revised with removed and combined factors. Revised conceptual model is given in Figure 16. Screenshot of the model built in SPSS Amos software is given in Appendix 3. Correlations between exogenous variables and error terms are not shown to keep the figure legible.

Estimates for the initial conceptual model are calculated with the collected data to test and validate the hypotheses. The AMOS output shows that there is a glaring issue beyond insignificant relations or poor goodness of fit indices. The covariance matrix between variables is found to be not positive definite, which means some of the eigenvalues of the matrix are not positive. This might be caused by high linear dependency between two variables in the model [58]. When the input covariance matrix is not positive definite, maximum likelihood method (which is used by AMOS for estimations) performs poorly, therefore the software simply gives an error message saying the solution is not admissible. To fix this error, highly correlated items can be removed from the model to get rid of linear dependencies, or if it is a case of a model misspecification the model and relations between variables can be rebuilt.

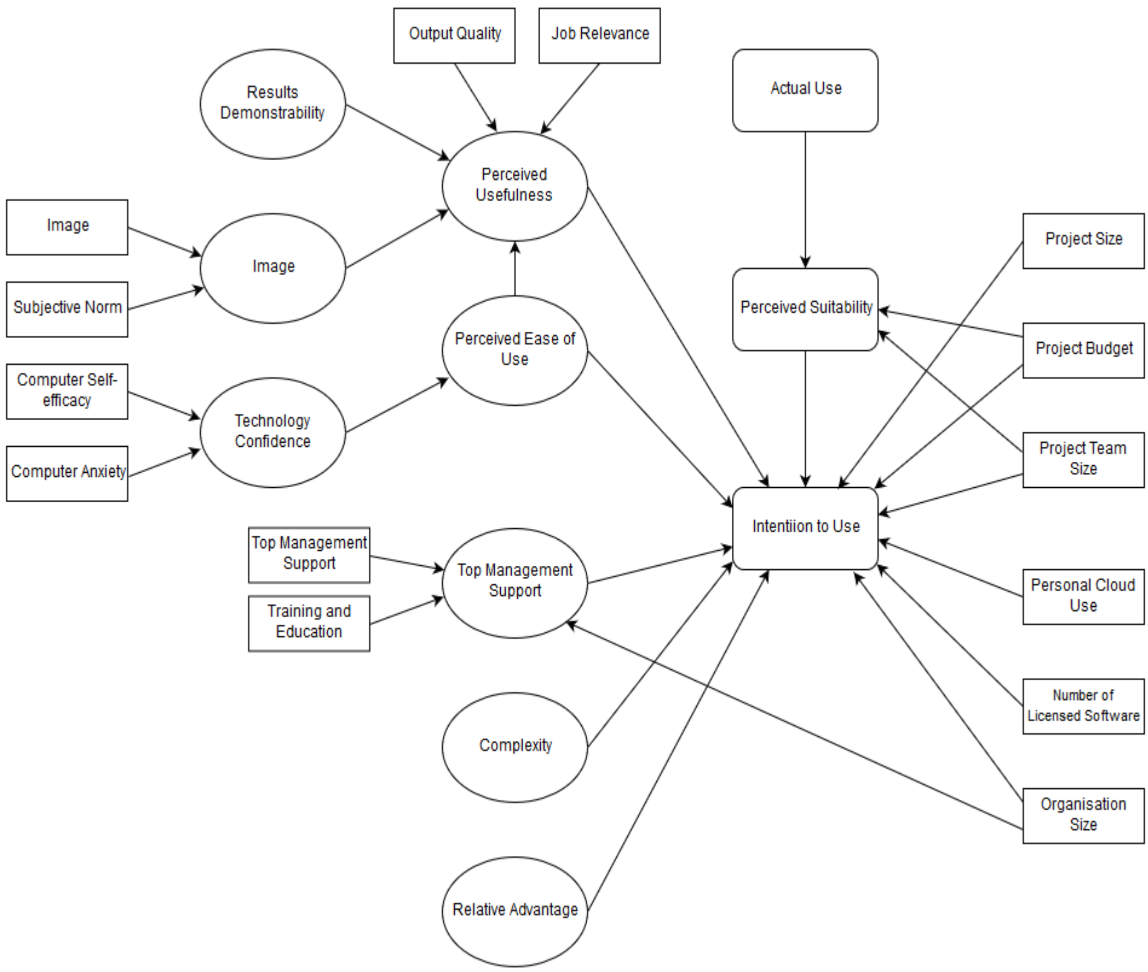

Figure 16: Revised conceptual model

4.4. Exploratory SEM Analysis

AMOS software offers modification indices to suggest correlations and regressions to add to the model. In the modification indices tab of the output, the possible additions are listed with how much they would improve the model (the chi-square value of the model) if they are applied. Furthermore, significance probabilities (p-values) of suggested relations can be checked in the estimates tab of the output to remove insignificant relationships from the model to achieve model parsimony. These additions and removals must be done one by one and the model must be calculated again after each modification. These steps are beyond the scope of confirmatory studies, hence this study at this point becomes an exploratory study of the cloud adoption model (Byrne, 2016; Blunch, 2012).

Another issue to solve before the model modifications is that even though AMOS has its own method of dealing with incomplete data (Full Information Maximum Likelihood, FIML), when this method is used to calculate the model with incomplete data, the software cannot suggest modification indices. At this point, an alternative imputed data set is generated by filling in the missing observations and responses with the median of values of each variable. SEM model is calculated with the complete (imputed) data and every modification (addition and removal of correlations and regressions) is applied to both models with original incomplete data (which still uses the FIML method to handle missing data) and the complete imputed data. It is seen that every modification suggested by AMOS based on the imputed data did indeed improve the model with the original incomplete data as well.

The final model is reached after these modification steps. The correlations and regressions between variables are revised and updated while following AMOS modification indices for additions and p-values for removals. All the modifications are applied not just based on statistical and numerical improvement of the model but actual variables and what they measure are taken into consideration. Only the logical modifications are applied and once it is determined that no further modification makes sense, the improvement of the model is stopped. The final model can be seen in Figure 17. Correlations between exogenous variables and error terms are not shown to keep the figure legible. Goodness of fit indices are improved as best as they could and the model has only statistically significant correlation and regression relations for the sake of parsimony.

The chi-square value of the model is 993.229 with 366 degrees of freedom. P-value for the chi-square is 0.001. The null hypothesis for the chi-square test is that the model fits the data (meaning, the population covariance matrix produced by SEM based on the model is not significantly different than the sample covariance matrix based on collected data). Scholars require the p-value for the test to be greater than 0.05 so that the null hypothesis that states that the model fits the data fails to be rejected. However, when sample size is large enough, it is possible to have a low p-value even though model does indeed fit the data [60]. This is why the model is not rejected just based on the chi-square test and further goodness of fit indices are examined. These indices are suggested by different researchers and the justification for using them is explained in relevant studies in the literature [59].

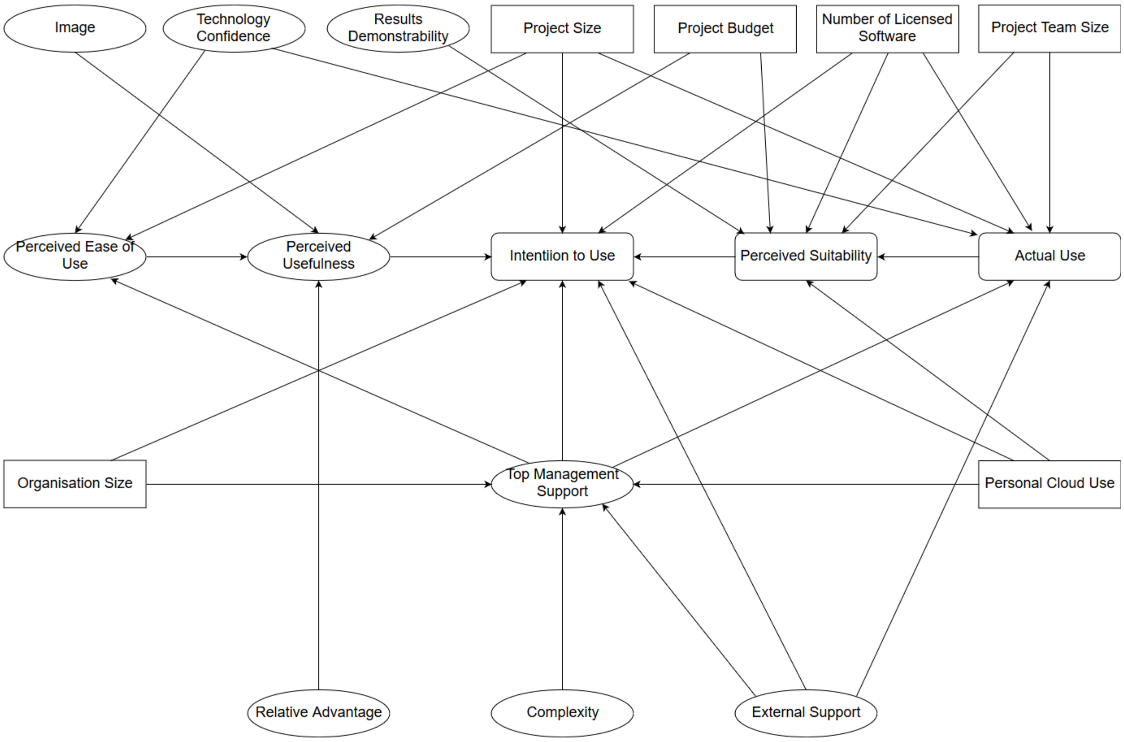

Figure 17: Final model after exploratory analyses

CMIN/DF ratio is found as 2.714. For a good model fit to data, this value is desired to be between 2 and 3, which means that there is an acceptable fit in this study's final model. RMSEA values closer to 0.06 (in the 0.04-0.07 interval for the best fit) mean better fit to data. The model in this study has an average of 0.080 for the RMSEA value with the lower ten percentile falling around the value of 0.074. CFI values are desired to be close to 1 (greater than 0.95 for best fit), which in this study is found as 0.803. While these goodness of fit indices are not exactly at the desired levels, they are close enough to the thresholds which implies a good enough fit to data. As the modification indices did not suggest any further logical changes to the model in the exploratory steps, the study had to stop the improvements at this point to prevent obtaining an overfitting model to reach better goodness of fit indices.

The final model is found to explain 69.6% of the changes in intention to use cloud in software development with the variables and relationships in the model. This is a good amount of variance explained for a complex behavioural model and on the same level as previous cloud adoption studies analysed in the SLR part of this thesis. This model also shows which of the initial hypotheses are confirmed. Standard regression weights of the pairwise relations in the final model are shown on the model in Figure 18. Table 15 summarises the rejected hypotheses that were about pairwise relations that are removed in the final model. The accepted hypotheses with their standardised regression weights and the significance levels (p-values) are given in

Table 16. Additional significant relationships discovered with the exploratory SEM analyses on the model that were not initially hypothesised are given in Table 17 with their respective standardised regression weights and significance levels.

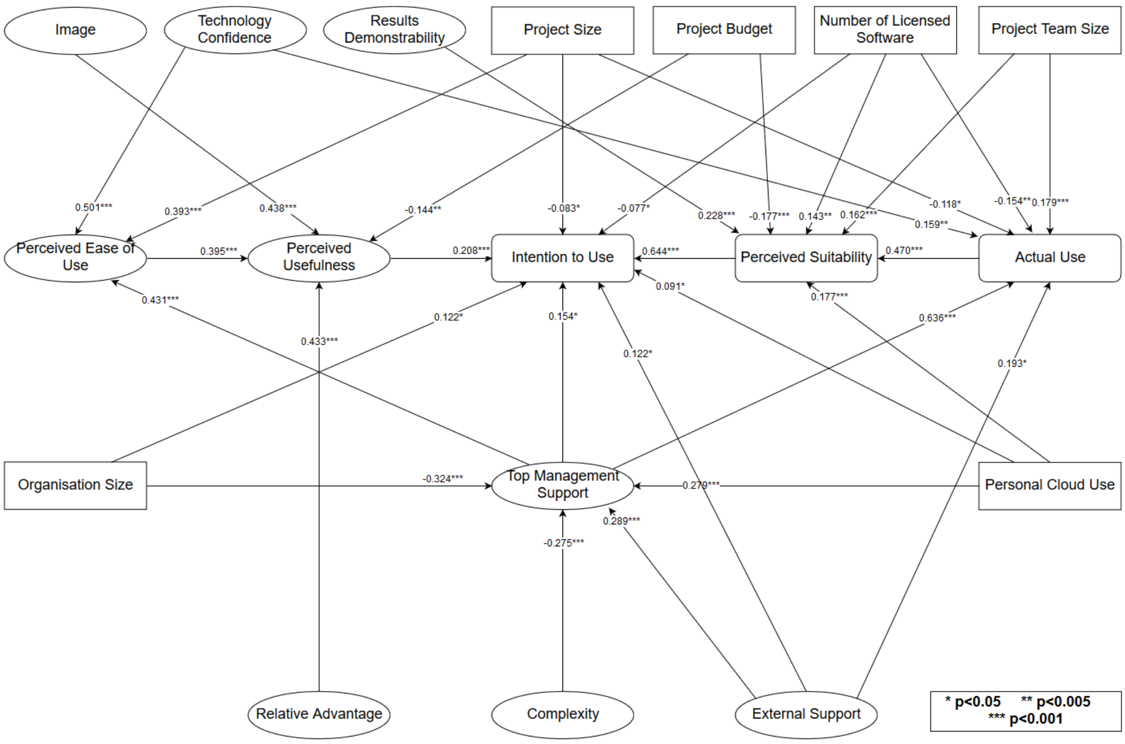

Figure 18: Final model with std. regression weights

Table 15: Rejected hypotheses

		Rejection reason
H2a	Perceived ease of use → Intention to use	No significant effect
H3	Results demonstrability → Perceived usefulness	No significant effect
H7	Complexity → Intention to use	No significant effect
H8	Relative advantage → Intention to use	No significant effect
H12a	Project budget → Intention to use	No significant effect
H13a	Project team size → Intention to use	No significant effect

Table 16: Accepted hypotheses

		Std. Reg. Wt.	p-value
H1	Perceived usefulness → Intention to use	0.208	<0.001
H2b	Perceived ease of use → Perceived usefulness	0.395	<0.001
H4	Image → Perceived usefulness	0.438	<0.001
H5	Technology confidence → Perceived ease of use	0.501	<0.001
H6	Top management support → Intention to use	0.154	<0.05
H9	External support → Intention to use	0.122	<0.05
H10	Personal cloud use → Intention to use	0.091	<0.05
H11	Project size → Intention to use	-0.083	<0.05
H12b	Project budget → Perceived suitability	-0.177	<0.001
H13b	Project team size → Perceived suitability	0.162	<0.001
H14a	Organisation size → Intention to use	0.122	<0.05
H14b	Organisation size → Top management support	-0.324	<0.001
H15	Number of licensed software → Intention to use	-0.077	<0.05
H16	Actual use → Perceived suitability	0.470	<0.001
H17	Perceived suitability → Intention to use	0.644	<0.001

The final model shows that 15 of the 21 initial hypotheses are validated and accepted while six of them are rejected due to finding no direct significant effect. No hypothesis is rejected for having an effect in the opposite direction of the hypothesis (i.e. negative effect is found where positive relationship was hypothesised, or vice versa). Five of these rejected relationships were assumed to have direct effects on intention to use and the other one on perceived usefulness. It is discovered that these five factors have indirect effects on intention to use and they directly affect other endogenous variables in the model such as perceived suitability, actual use, perceived usefulness, perceived ease of use, and top management support which then affect intention to use. There are no new discovered direct effects on intention to use, instead the effects in the model are split onto the three-piece structure of "actual use – perceived suitability – intention to use". Relative advantage from TOE structures is found to have effects on the key factors of TAM (perceived usefulness) instead of directly affecting intention. Top management support is found to have direct effect on the key factors of TAM (perceived ease of use) in addition to directly affecting intention.

Discovered relationships must be examined one by one to make sure they are logical and consistent within the context of the study (using cloud technologies for software development activities in SDOs) beyond being only numerically and statistically significant. If they do not make sense in the context of the study, the model might need a revision. If they are logical relationships, they may give insights about a specific part of the system that was gone unnoticed prior to the analyses.

4.4.1. Discovered Effects on Perceived Usefulness

Increases in project budget have a negative effect on perceived usefulness. This is consistent with the initially hypothesised effect of project budget on perceived suitability. Projects with more limited budgets are believed to benefit from cloud technologies more than projects with higher allowances. The model and the collected data suggest that developers who work on projects with smaller budget find cloud technologies more useful.

Another effect found on perceived usefulness is from relative advantage. Relative advantage is a factor that was adapted from the TOE framework and it was initially hypothesised to directly affect intention to use. The model modifications show that relative advantage, in this case, affects perceived usefulness instead. Looking at the questionnaire item that measures relative advantage, "*using cloud allows me to perform specific software development tasks faster"*, this effect is found completely logical.

Table 17: Discovered relations

		Std. Reg. Wt.	**p-value**
	Personal cloud use → Top management support	0.279	<0.001
	Complexity → Top management support	-0.275	<0.001
	External support → Top management support	0.289	<0.001
	Top management support → Perceived ease of use	0.431	<0.001
	Project size → Perceived ease of use	0.393	<0.001
	Project budget → Perceived usefulness	-0.144	<0.005
	Relative advantage → Perceived usefulness	0.433	<0.001
	Technology confidence → Actual use	0.159	<0.005
	Top management support → Actual use	0.636	<0.001
	Project size → Actual use	-0.118	<0.05
	Project team size → Actual use	0.179	<0.001
	Number of licensed software → Actual use	-0.154	<0.005
	External support → Actual use	0.193	<0.05
	Results demonstrability → Perceived suitability	0.228	<0.001
	Personal cloud use → Perceived suitability	0.177	<0.001
	Number of licensed software → Perceived suitability	0.143	<0.005

4.4.2. Discovered Effects on Perceived Ease of Use

Top management support (that is perceived by the individual developers in the form of both perceived management policies and actual education and training provided to them) positively affects their perception of ease of use of the cloud technologies for software development activities. This makes sense in both ways. An actual education and training provided to them in the company means that they will find new technologies easier to adopt and use. And the more support they perceive from their supervisors and managers, more confident they will be to accept new alternatives and get used to them more easily.

The other discovered relationship is more interesting. Project size is found to have a positive effect on perceived ease of use. This is interesting because project size was hypothesised to have a negative effect on intention to use which is confirmed, additionally it is discovered to have a similar negative effect on actual cloud use. Developers perceive the cloud technologies as easier to use for larger projects (in LOC), even though there is an overall decrease in actual current use and intention to adopt cloud technologies for such projects. Even though larger projects are more intimidating to migrate over a new platform, which explains why project size expectedly has a negative effect on actual use and intention, when individual developers are asked the question about their perception on ease of use of cloud technologies, they might not have answered only with their ongoing projects in mind and they might prefer to begin working on new large projects on cloud platforms from the start. Therefore, this difference in effects of project size might be explained by the difference between developers' personal perceptions on cloud technologies and their perception on the ongoing projects in the context of their organisation and management.

4.4.3. Discovered Effects on Top Management Support

There are three additional effects discovered on top management support perceived by developers. Personal cloud use and external support are found to positively affect top management support while complexity has a negative effect on it. While external support is related to top management support as a whole, other two effects are related to the training and education part of the top management support more than they are to the perceived support by management level. Both perceived complexity and personal cloud use of developers in their daily life measure their competence at using the cloud technologies in software development activities and this perception is also related to the level of training provided to them by the management.

4.4.4. Discovered Effects on Actual Use

In the initial model actual use was assumed to be an exogenous variable that affects perceived suitability (which then affects intention to use) in the suggested three-piece structure to replace the sole intention to use variable in traditional models. After modifications it is found that actual use also is directly affected by other factors in the model while still keeping the three-piece structure of actual use → perceived suitability → intention to use.

Actual use, unlike perceived suitability or intention to use, is not a personal perception, a behaviour, or a belief. It is the actual current state of the cloud use in software development activities for the currently active projects of developers. It measures the degree to which cloud technologies are utilised in ten different phases of software life cycle on a Likert scale from 1 (never) to 5 (always). Five of them are the core steps of a software project: requirements management, design, coding, test, and deployment. Other five activities are maintenance, configuration management, documentation, quality assurance, and project management. The detailed rundown of actual cloud use in software development activities in the SDOs that participated in the questionnaire is given in Table 18.

It can be seen that the respondents who always use cloud technologies in any of the software development activities never exceed the 10% of the sample. Mean values of responses for all ten activities are below the average of the scale (2.5). A big portion of the sample never use cloud for software development currently. Examining the factors discovered to have direct effects on actual use, top management support is found to be the biggest factor with the greatest regression weight and highest significance level. Even in the cases where developers would be likely to use cloud technologies, it is usually not preferred to adopt on the managerial level.

In addition to top management support; project team size, technology confidence, and external support are other factors that have direct positive effects on actual use. Projects with larger team sizes are more likely to already have adopted cloud technologies because of the several benefits of cloud technologies with regards to easier management, coordination, communication, and accessibility in the projects. Technology confidence is a personal factor that makes cloud technologies more tempting to use for developers. Developers’ perceived external support means that they are more likely to have already adopted related technologies in their work.

Table 18: Descriptive statistics and frequencies for actual current cloud use

Activity	Mean	St. Dev.	Never	Rarely	Sometimes	Often	Always
Requirements	2.07	1.28	122	30	39	37	9
Design	1.94	1.17	130	42	52	15	11
Coding	2.30	1.44	119	29	40	38	26
Test	2.04	1.30	131	42	34	31	15
Deployment	2.32	1.50	126	20	28	51	25
Maintenance	1.93	1.32	144	32	28	22	18
Configuration	2.12	1.43	121	24	18	39	17
Documentation	2.45	1.41	99	27	49	48	21
Quality	1.95	1.37	133	21	27	18	20
Project Mgmt.	2.38	1.45	95	19	46	28	25

Project size and number of licensed software are the factors that negatively affect the actual cloud use. These two factors were initially hypothesised to have negative effects on intention to use and in the final model these effects are confirmed. In addition to the potential adoption scenarios, they are discovered to have similar negative effects in the current cloud use cases as well. These, again, are logical in the context of this study.

4.4.5. Discovered Effects on Perceived Suitability

Similar to the key factors of TAM (perceived ease of use and perceived usefulness), perceived suitability is a personal factor suggested in this study to directly affect intention to use. It was initially assumed to be affected by only the project characteristics (budget and team size) because even for the same developer this perception can differ from project to project. These two effects are confirmed. Additionally, more factors in the model are discovered to directly affect developers' perception of suitability of cloud technologies to their current project.

Results demonstrability which was initially assumed to increase the users' perceived usefulness is instead found to increase users' perceived suitability. Personal cloud use of developers in daily non-professional life similarly has a positive effect on their perceived suitability of cloud technologies to their professional work. Lastly, number of licensed software used in the project is discovered to have a positive effect on perceived suitability.

Last one deserves a special examination because the same variable is also found to have negative effects on actual use and intention to use. How is it that when the amount of licensed official software purchased and used for the project increases, respondents are more likely to find cloud technologies for these projects more suitable but the actual current use and intention to adopt cloud decrease? The licensed official software packages purchased for the project are usually proprietary, commercial alternatives and these purchases are made by the management and not the developers themselves. In the case of having already purchased the expensive, proprietary programs; management of the companies might not be interested in immediately moving to cloud technologies which support the open source alternatives and make the purchased software redundant in some version of a sunk cost fallacy. Managers' lack of interest in the migration to cloud, in this case, might negatively affect the current cloud use and the intention of developers to adopt because top management support is found to have a greater effect on their perception of ease of use and intention. But at the same time, developers see that the project uses a large amount of officially licensed software programs and they might be inclined to believe that the project, for that reason, would be more suitable for cloud technologies. This is an interesting discovery which emphasises the differences in the point of view of managers and developers in the same system which also affect each other.

All the new suggested relationships in the model are examined and found to be logical and consistent within the context of the study and the sample. Furthermore, as this was the intended outcome of exploratory analyses, they give more insight to what affects intention to use cloud technologies in software development activities by developers in projects and companies with different characteristics than what was initially hypothesised. Both statistically significant and realistically meaningful conclusions can be drawn from the results of the analysis.

5. CONCLUSION

5.1 Conclusions of SLR and Open Issues

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.

Since practical use cases for cloud technologies began to be realised 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. The adoption and usage cases are taken from mainly four different study domains: business, personal use, education, and healthcare.

Technology acceptance theories and behavioural 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 & 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.

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 healthcare or education are also being conducted. However, cloud technologies today are even further specialised for specific areas and domains and there are specialised 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 like the primary research of this thesis.

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 behaviour 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 behaviour.

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 utilise SEM and instead use different statistical methods. With such a study, comparisons between SEM and alternative methods in similar studies may be analysed. 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.

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 who are either individual users or large-scale organisations 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.

5.2 Limitations and Future Work for Primary Study

The primary study of this thesis has reached meaningful results and it allows conclusions to be drawn from the findings for the future. However, it is not without its limitations.

Firstly, the goodness-of-fit values of the adoption model with regards to the collected data can be improved. This can be done by the addition of different factors into the model that were not suggested in this study. Additionally, increase in the sample size might improve the indices. Even though the sample size of this study is enough to draw conclusions about the population, larger sample size with more observations and data can always improve the models.

The data is collected from software developers, project leaders, and high level managers in SDOs in Ankara, Turkey. In future studies same questionnaire might be applied in different geographical locations to extend the model or compare the results between studies. However, this geographical location limitation is common in all information systems studies and it does not prevent the claims and conclusions about generality of results [61].

5.3. Threats to Validity

Construct Validity: Errors while measuring the variables might occur due to miscommunication between researchers and respondents on the questionnaire items. To reduce this risk, questionnaire for this study is conducted in personally administered sessions in organisations that participated. Questionnaire sessions are arranged according to their schedule and in their own offices, researcher has always been present during the questionnaire sessions to clarify anything needed by respondents. Items in the questionnaire are worded as clear as possible with avoiding technical terms that could create confusion. Respondents were also allowed to skip questions they were not certain about.

As for SLR part of this thesis, potential missing search keywords (hence, potential missing articles) might be a threat to construct validity. Search keywords that cover all the possible results without being either too wide or too narrow are aimed to be selected to minimise this threat. Moreover, potential threats due to subjectivity and personal prejudice during the inclusion and exclusion of the articles are overcome by defining strict inclusion and exclusion criteria and conducting this process with the group of researchers instead of completing it individually. Cross checks by the researchers are used to ensure the data is extracted from the article pool accurately and correctly.

Internal validity: Causal relationships between variables that were not considered to be included in the model might cause internal validity threats [62]. The variables that are in the conceptual model are analysed upon collecting data using exploratory factor analysis and variables are revised after the analyses to make sure all the relations in the final model are as intended and there are no casual relations or correlations that would affect the outcome.

External validity: Threats to external validity are potential limits to the ability to generalise the study results to a larger scope [62]. Selection of respondents, sample size, and changes to technology and people’s perceptions of the technology over time might cause generalisation limitations. Respondents in this study are chosen as developers, project managers, and senior managers in SDOs in Ankara, Turkey who are currently working on software development projects. Researchers contacted high level managers in SDOs for questionnaire arrangements and managers in organisations organised participants from relevant projects. Careful selection of participants, personally administered questionnaire sessions, and the sample size are argued to have no limitations to generalisation of the results. Regarding the change in technology and people's perception of the technology over time; it is argued that at the current rate of developments in cloud technologies for software development and developers' perception of cloud, results of the study will remain applicable over time.

Conclusion validity: Conclusion validity is whether the study is reproducible or not. SLR part of this thesis strictly follows the guideline of systematic review and all the articles in the final pool and the extracted data are saved rigorously so that any future similar review can trace the steps of review and reach the same results. For the primary study, all models and variables are defined carefully and the collected anonymous data is well-stored. Software and algorithms used for statistical analyses are widely used in the literature for meaningful results. We believe that with the same model and the data, the primary study is entirely reproducible and other researchers would reach the same results and conclusions.

5.4. Primary Study Conclusions

Cloud computing in the last decade has become a technology in practical use in daily lives of individuals as well as in business activities of organisations. With the increase in cloud usage and its popularity, more specific cloud based solutions are developed for particular areas. Software development is one of these areas because it is an extensive task which consists of many phases and activities and cloud based solutions might help developers improve their performance. However, it is important to analyse which cloud based solutions would indeed improve the performance and output and which ones would actually hinder if used over traditional methods that developers might feel more comfortable to use.

Adopting new technologies like migrating the software development activities to cloud is a decision that should be made after the analysis of situation. In order to analyse it, the factors that affect the intention to adopt a new technology positively and negatively should be assessed and validated. This thesis aims to do this by focusing on cloud usage in software development projects in Turkey.

Before drawing conclusions about the population, the behavioural model used in this study itself is tested and validated. Theories from literature like TAM and TOE are employed to design a hybrid conceptual model which also includes the novel suggestions of this thesis. Upon receiving the results of the confirmatory study, the conceptual model is revised and improved with exploratory analysis steps. Thus, both the revised theoretical model is validated to be used in similar studies in the future and it is made possible to draw specific conclusions about the population selected for this study.

From the collection of data, it can be seen that current actual use of cloud in software development activities is not a common practice in Turkey. Organisations prefer to keep the software activities on their own dedicated servers (physical or private virtual servers on premise) and this is due to several different factors. Lack of interest by management, the requirements of the sector (e.g. defence industry and their high privacy measures), or users wanting to avoid the initial cost of migration (both financial cost and effort required to get used to the new technology) can be listed as potential avoidance reasons. The organisations that are currently using cloud technologies are mostly smaller scale start-up companies or larger firms with more innovative management teams who follow new developments closely.

Integrating variables about the characteristics of projects and organisations is found to improve the hybrid adoption model that is based on TAM and TOE theories. Additionally, the hypothesised positive relations between the variables “actual use”, “perceived suitability”, and “intention to use” are confirmed.

According to the conceptualised and validated model, personal perceptions of a new technology play a significant role in accepting that technology over current methods. In addition to personal factors, if developers feel that their top management supports the new technology, they are much more likely to want to use it. Project characteristics affect team members' intention to adopt and use cloud more than organisational factors. It can be said that it is not fair to make one singular decision regarding cloud use per organisation, instead projects should be considered separately. Even in the same organisation, different projects require different solutions.

When the model is revised and final structure of cloud adoption in software development activities by software development teams in Turkey is reached, it is found that there are several discovered relations that weren't initially hypothesised. Actual use of cloud was predicted to be an exogenous variable in the model that directly affects perceived suitability, and then intention to use indirectly. However, it is found that effects of causal factors on the current cloud use also should be taken into consideration for a more accurate model, which means actual use is also an endogenous variable whose change is explained by other variables in the model. In addition to that, it is discovered that as projects get larger (higher amount of line of code, more software tools required to complete the different steps of the project), developers will find cloud technologies more suitable to the project while management will be less likely to make the migration to cloud decision. Even in the cases where management does not support the adoption of cloud technologies for the current software projects, they can be beneficial for future projects if they are to be used from the start.

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APPENDICES

APPENDIX 1 – Selected Article Pool of SLR

ID	Reference	Title
S01	[63]	Analyzing Factors Affecting the Adoption of Cloud Computing: A Case of Turkey
S02	[64]	The drivers or ERP cloud computing from an institutional perspective
S03	[65]	Determining the enabling factors for implementing cloud data governance in the Saudi public sector by structural equation modelling
S04	[66]	An exploration of the determinants for decision to migrate existing resources to cloud computing using an integrated TOE-DOI model
S05	[67]	An empirical study of factors influencing cloud adoption among private sector organisations
S06	[68]	Exploring users' attitudes and intentions toward the adoption of cloud computing in Saudi Arabia: an empirical investigation
S07	[69]	A Review on Cloud Computing Acceptance Factors
S08	[70]	Understanding and predicting students' intention to use mobile cloud storage services
S09	[71]	Antecedents and consequences of cloud computing adoption in education to achieve knowledge management
S10	[72]	Effects of security and privacy concerns on educational use of cloud services
S11	[73]	Customers perspectives on adoption of cloud computing in banking sector
S12	[74]	A transaction cost theoretical analysis of software-as-a-service (SAAS)-based sourcing in SMBs and enterprises
S13	[75]	Opportunities and risks of software-as-a-service: Findings from a survey of IT executives
S14	[76]	Drivers of SaaS-adoption--an empirical study of different application types
S15	[77]	Investigating the structural relationship for the determinants of cloud computing adoption in education
S16	[78]	Why end-users move to the cloud: a migration-theoretic analysis
S17	[79]	Cloud computing, Web 2.0, and operational performance: the mediating role of supply chain integration
S18	[80]	Supply chain integration through community cloud: Effects on operational performance
S19	[81]	The role of trust and risk perceptions in cloud archiving—Results from an empirical study
S20	[82]	Establishing the use of cloud computing in supply chain management

ID	Reference	Title
S21	[83]	Antecedents and optimal industrial customers on cloud services adoption
S22	[83]	A Comparison of Competing Models for Understanding Industrial Organization's Acceptance of Cloud Services
S23	[84]	Cloud computing and trust evaluation: A systematic literature review of the state-of-the-art mechanisms
S24	[85]	An integrative framework of comparing SaaS adoption for core and non-core business operations: An empirical study on Hong Kong industries
S25	[86]	A Systematic Literature Review on Cloud Computing Adoption and Migration
S26	[87]	User acceptance of software as a service: Evidence from customers of China's leading e-commerce company, Alibaba
S27	[88]	A literature review on cloud computing adoption issues in enterprises
S28	[89]	Acceptance of health clouds-a privacy calculus perspective
S29	[90]	Cloud computing usage and its effect on organizational performance
S30	[91]	Critical factors of cloud computing adoption in organizations: An empirical study
S31	[41]	Understanding determinants of cloud computing adoption using an integrated TAM-TOE model
S32	[92]	Understanding cloud computing adoption: A model comparison approach
S33	[93]	Cloud computing as a tool for enhancing ecological goals?
S34	[94]	The usage and adoption of cloud computing by small and medium businesses
S35	[95]	Compliance, network, security and the people related factors in cloud ERP implementation
S36	[96]	Moderating effect of compliance, network, and security on the critical success factors in the implementation of cloud ERP
S37	[97]	Risk-Benefit-Mediated Impact of Determinants on the Adoption of Cloud Federation
S38	[98]	The Research of User Satisfaction Model in Hybrid Cloud Environment
S39	[99]	Organisational factors affecting cloud computing adoption in small and medium enterprises (SMEs) in service sector
S40	[100]	Predicting the acceptance of cloud-based virtual learning environment: The roles of Self Determination and Channel Expansion Theory
S41	[101]	Do You Trust the Cloud? Modeling Cloud Technology Adoption in Organizations
S42	[102]	Trust or consequences? Causal effects of perceived risk and subjective norms on cloud technology adoption

ID	Reference	Title
S43	[103]	Healthcare professionals' use of health clouds: Integrating technology acceptance and status quo bias perspectives
S44	[104]	An empirical investigation of patients' acceptance and resistance toward the health cloud: The dual factor perspective
S45	[105]	Explaining resistance to system usage in the PharmaCloud: A view of the dual-factor model
S46	[106]	Factors affecting the adoption of cloud services in enterprises
S47	[107]	The factors that predispose students to continuously use cloud services: Social and technological perspectives
S48	[108]	Outlining the Issues of Cloud Computing and Sustainability Opportunities and Risks in European Organizations: A SEM Study
S49	[109]	Understanding socio-technical impacts arising from software-as-a-service usage in companies
S50	[110]	Switching attitudes of Taiwanese middle-aged and elderly patients toward cloud healthcare services: An exploratory study
S51	[111]	Two-dimensional fairness on service recovery satisfaction in cloud computing
S52	[112]	Integrating TRA and TOE Frameworks for Cloud ERP Switching Intention by Taiwanese Company
S53	[113]	Research on the Service Innovation Path for Information Platform in the Cloud Computing Environment
S54	[114]	Tourism guide cloud service quality: What actually delights customers?
S55	[115]	An empirical investigation of the effects of firm characteristics on the propensity to adopt cloud computing
S56	[116]	Drivers and Inhibitors for the Adoption of Public Cloud Services in Germany
S57	[117]	Environment determinants in business adoption of Cloud Computing
S58	[118]	An empirical analysis to assess the determinants of SaaS diffusion in firms
S59	[119]	Examining Cloud Computing Adoption Intention in Higher Education: Exploratory Study
S60	[120]	A study of personal cloud computing: compatibility, social influence, and moderating role of perceived familiarity
S61	[121]	Acceptance and use of information system: E-learning based on cloud computing in Vietnam
S62	[39]	Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors
S63	[122]	Cloud computing in manufacturing: The next industrial revolution in Malaysia?

ID	Reference	Title
S64	[123]	Impact of service value on satisfaction and repurchase intentions in business-to-business cloud computing
S65	[124]	An integrated adoption model of mobile cloud services: exploration of key determinants and extension of technology acceptance model
S66	[125]	An empirical study on the influential factors affecting continuous usage of mobile cloud service
S67	[126]	Innovation-diffusion determinants of cloud-computing adoption by Pakistani SMEs
S68	[127]	A survey study on major technical barriers affecting the decision to adopt cloud services
S69	[128]	Understanding and predicting the determinants of cloud computing adoption: A two staged hybrid SEM-Neural networks approach
S70	[129]	Evaluating the usage of cloud-based collaboration services through teamwork
S71	[130]	Identifying the moderating effect of trust on the adoption of cloud-based services
S72	[131]	A structural equation modeling approach for the adoption of cloud computing to enhance the Malaysian healthcare sector
S73	[132]	Social Cognitive Theory and the Technology Acceptance Model in the Cloud Computing Context: The Role of Social Networks, Privacy Concerns and Behavioural Advertising
S74	[133]	Continuance use intention of cloud computing: Innovativeness and creativity perspectives
S75	[134]	Service innovations in cloud computing: a study of top management leadership, absorptive capacity, government support, and learning orientation
S76	[51]	Analyzing the factors influencing cloud computing adoption using three stage hybrid SEM-ANN-ISM (SEANIS) approach
S77	[135]	Conceptualizing a model for adoption of cloud computing in education
S78	[136]	A cross-country model of contextual factors impacting cloud computing adoption at universities in sub-Saharan Africa
S79	[137]	Staff perception towards cloud computing adoption at universities in a developing country
S80	[138]	Cloud computing and its impact on economic and environmental performance: A transaction cost economics perspective
S81	[139]	Security and privacy concerns for australian SMEs cloud adoption: empirical study of metropolitan vs regional SMEs
S82	[140]	Adoption of security as a service
S83	[141]	Cloud Computing Issues for Higher Education: Theory of Acceptance Model

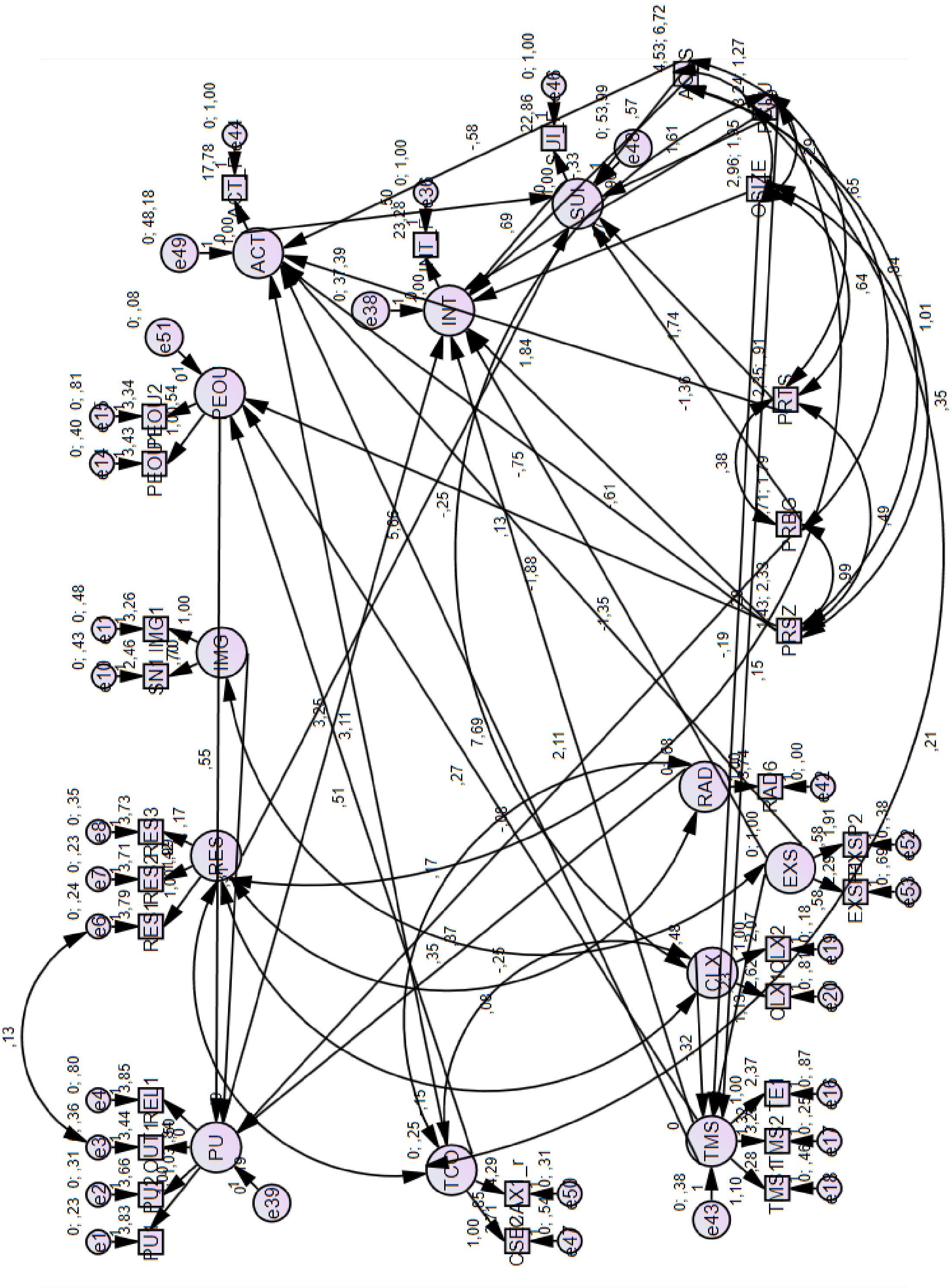
ID	Reference	Title
S84	[142]	Understanding behavioral intention to use a cloud computing classroom: A multiple model comparison approach
S85	[143]	User centric cloud service model in public sectors: Policy implications of cloud services
S86	[144]	Beyond user experience of cloud service: Implication for value sensitive approach
S87	[145]	Factors influencing the organizational adoption of cloud computing: a survey among cloud workers
S88	[146]	Logistics and cloud computing service providers' cooperation: a resilience perspective
S89	[147]	User acceptance of SaaS-based collaboration tools: a case of Google Docs
S90	[148]	Cloud computing adoption by higher education institutions in Saudi Arabia: an exploratory study
S91	[149]	Uncertainty in cloud service relationships: Uncovering the differential effect of three social influence processes on potential and current users
S92	[150]	How to Succeed with Cloud Services? A Dedication-Constraint Model of Cloud Success
S93	[151]	Bridging Knowledge Divides Utilizing Cloud Computing Learning Resources in Underfunded Schools: Investigating the Determinants
S94	[152]	Developing an explorative model for SaaS adoption
S95	[153]	Understanding Chinese users' switching behaviour of cloud storage services
S96	[154]	Predicting the adoption of cloud-based technology using fuzzy analytic hierarchy process and structural equation modelling approaches

APPENDIX 2 – Questionnaire

ID	QUESTION	SOURCE
PU1	Using cloud for software development improves my performance.	Venkatesh and Bala [26]
PU2	Using cloud for software development increases my productivity.	Venkatesh and Bala [26]
OUT1	The results of my work is good when I use cloud for software development.	Venkatesh and Bala [26]
REL1	Usage of cloud is relevant in my job.	Venkatesh and Bala [26]
RES1	The results of using cloud for software development are apparent to me.	Venkatesh and Bala [26]
RES2	I believe I could communicate to others the consequences of using cloud for software development.	Venkatesh and Bala [26]
RES3	I would not have difficulty explaining why using cloud for software development may or may not be beneficial.	Venkatesh and Bala [26]
SN1	People who influence my behaviour think that I should use cloud for software development.	Venkatesh and Bala [26]
IMG1	Using cloud for software development is prestigious.	Venkatesh and Bala [26]
PEOU1	Interacting with cloud when developing software is clear and understandable.	Venkatesh and Bala [26]
PEOU2	Interacting with cloud when developing software does not require a lot of my mental effort.	Venkatesh and Bala [26]
CAX1	Developing software on cloud scares me.	Venkatesh and Bala [26]
CSE1	I can complete software development tasks on cloud even if there is no one to show me how to do it first.	Venkatesh and Bala [26]
TMS1	My company’s management supports (e.g. providing resources, taking risks, etc.) the adoption of cloud for software development.	Oliveira et al. [39]
TMS2	My company’s management understands the benefits of using cloud for software development.	Lian et al. [40]
TE1	My company provided me training for using cloud for software development.	Gangwar et al. [41]
CLX1	I find it difficult to integrate my existing work with the cloud-based services	Gangwar et al. [41]
CLX2	I find the use of cloud computing to be too complex for software development operations.	Oliveira et al. [39]
EXSP1	I think the existing laws and regulations are sufficient to protect the use of cloud for software development.	Oliveira et al. [39]
EXSP2	I think using cloud for software development is becoming one of the government major policies.	Lian et al. [40]
RAD1	Using cloud allows me to perform specific software development tasks faster.	Oliveira et al. [39]
INT…	I would want to use cloud computing in my project in the phase of …………	Çoban et al. [42]
INT1	requirement management.	
INT2	design.	
INT3	coding and development.	
INT4	test.	
INT5	deployment.	
INT6	maintenance.	
INT7	configuration management.	
INT8	documentation.	

INT9	quality assurance.	
INT10	project management.	
SUI…	I find cloud computing suitable in my project in the phase of …………	Çoban et al. [42]
SUI1	requirement management.	
SUI2	design.	
SUI3	coding and development.	
SUI4	test.	
SUI5	deployment.	
SUI6	maintenance.	
SUI7	configuration management.	
SUI8	documentation.	
SUI9	quality assurance.	
SUI10	project management.	
ACT…	I am currently using cloud computing in my project in the phase of …………	Çoban et al. [42]
ACT1	requirement management.	
ACT2	design.	
ACT3	coding and development.	
ACT4	test.	
ACT5	deployment.	
ACT6	maintenance.	
ACT7	configuration management.	
ACT8	documentation.	
ACT9	quality assurance.	
ACT10	project management.	
PRSZ	What is the estimated size of your current software project in KLOC (kilo line of code)?	Garousi et al. [3]
PRBG	What is the budget of your project?	Garousi et al. [3]
PRTS	What is the team size of your current software project?	Garousi et al. [3]
PCLU	How many of the following cloud services do you currently use in your personal life?	Garousi et al. [3]
NOLS	How many of the following licensed tools and software do you use in your current software project with a license fee?	Garousi et al. [3]
ORSZ	How many employers work in your organisation?	Garousi et al. [3]

APPENDIX 3 – SEM Model in SPSS Amos



APPENDIX 4 – Ethics Board Approval

Tarih: 25.09.2018 15:50
Sayı: 35853172-300-E.00000241057

E.00000241057

T.C.
HACETTEPE ÜNİVERSİTESİ
Rektörlük

Sayı : 35853172-300
Konu : Erhan Pişirir Hk.

FEN BİLİMLERİ ENSTİTÜSÜ MÜDÜRLÜĞÜNE

İlgi : 11.09.2018 tarihli ve 23154132-300/00000225441 sayılı yazı.

Enstitünüz Endüstri Mühendisliği Anabilim Dalı Tezli Yüksek Lisans Programı öğrencilerinden **Erhan PİŞİRİR**'in **Doç. Dr. Oumout CHOUSEINOGLU** danışmanlığında yürüttüğü **"Bulutta Yazılım Geliştirmeyi Etkileyen Faktörlere Dayalı Bir Karar Destek Sistemi"** başlıklı tez çalışması,Üniversitemiz Senatosu Etik Komisyonunun **18 Eylül 2018** tarihinde yapmış olduğu toplantıda incelenmiş olup, etik açıdan uygun bulunmuştur.

Bilgilerinizi ve gereğini saygılarımla rica ederim.

e-imzalıdır
Prof. Dr. Rahime Meral NOHUTCU
Rektör Yardımcısı

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Duygu Didem İLERİ

MG

Öğrenciye bilgi verildi

APPENDIX 5 - Publications Based on the Thesis

E. Pişirir, E. Uçar, O. Chouseinoglou, C. Sevgi, Structural equation modelling in cloud computing studies: A systematic literature review, Kybernetes (**2019**).

E.Pişirir, O. Chouseinoglou, C. Sevgi, E. Uçar, Factors affecting the adoption of cloud for software development, Information and Software Technology, (**Submitted**).

E. Pişirir, C. Sevgi, O. Chouseinoglou, E. Uçar, "Türkiye'de Yazılım Geliştirme Takımlarının Bulut Kullanımı, Kullanım İsteği ve Uygunluk Algısı", UYMS2019 (**Submitted**).

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SCIENCE AND ENGINEERING
THESIS/DISSERTATION ORIGINALITY REPORT

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SCIENCE AND ENGINEERING
TO THE DEPARTMENT OF INDUSTRIAL ENGINEERING

Date: 03/07/2019

Thesis Title / Topic: **A structural equation model for understanding the use of cloud by software development teams - Yazılım geliştirme takımlarının bulut kullanımını anlamaya yönelik bir yapısal eşitlik modeli -**

According to the originality report obtained by ~~myself~~/my thesis advisor by using the *Turnitin* plagiarism detection software and by applying the filtering options stated below on 03/07/2019 for the total of **76** pages including the a) Title Page, b) Introduction, c) Main Chapters, d) Conclusion sections of my thesis entitled as above, the similarity index of my thesis is **9** %.

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I declare that I have carefully read Hacettepe University Graduate School of Sciene and Engineering Guidelines for Obtaining and Using Thesis Originality Reports; that according to the maximum similarity index values specified in the Guidelines, my thesis does not include any form of plagiarism; that in any future detection of possible infringement of the regulations I accept all legal responsibility; and that all the information I have provided is correct to the best of my knowledge.

I respectfully submit this for approval.

03/07/2019

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Program: Industrial Engineering

Status: ☒ Masters ☐ Ph.D. ☐ Integrated Ph.D.

ADVISOR APPROVAL

APPROVED.

Assoc. Prof. Dr. Oumout Chouseinoglou

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Hacettepe Journal of Mathematics and Statistics – Production Editor (2019 February - ...)

PROJECTS AND RESEARCH

Development of a Probabilistic Project Control Approach for Highly Risky and Uncertain Projects (2018 June - 2019 January)

REALM-AI: Interdisciplinary REseArch Links for Medical AI – Management of Musculo-skeletal Injury (2019 January - ...)

PUBLICATIONS

E. Pişirir, O. Chouseinoglou, C. Sevgi, E. Uçar, Structural Equation Modeling in Cloud Computing Studies: A Systematic Literature Review, Kybernetes (Accepted).