ADOPTION OF SOFTWARE DEVELOPMENT PRACTICES IN GLOBAL CONTEXT: AN EXPLORATORY STUDY

BY

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Dedication

To my parents and family, may Allah protect them with good health and happiness.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

GSD	Global Software Development
CBS	Component-based Software
OSS	Open-source Software
GD	Globally Distributed
DOI	Diffusion of Innovation
TOE	Technology-organization-environment
IS	Information Systems
PLS	Partial Least Square
SEM	Structural Equation Modeling
GD-CBS	Globally Distributed Component-based Software
GD-OSS	Globally Distributed Open-source Software
CBSD	Component-based Software Development
RTC	Round-the-clock
CR	Composite Reliability
AVE	Average Variance Extracted
VIF	Variance Inflation Factors

THESIS ABSTRACT

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Over the last decade, an increasing number of globally distributed software development projects have adopted Component-Based Software (CBS) development because of its potential to integrate and reuse components in new products, and Open-Source Software (OSS) development because of its potential to produce improvements in software quality and cost reductions in globally distributed projects. Moreover, globally distributed CBS development is a promising methodology to build cost effective quality software by independently developing software components in parallel by global teams. Similarly, globally distributed OSS development enables the development of software products by globally distributed teams in round-the-clock development without affecting code quality and productivity. As more organizations are embarking on globally distributed CBS development and *globally distributed OSS development, it is imperative for researchers and practitioners to identify and assess the determinants that influence organizations to adopt globally distributed CBS development and globally distributed OSS development methodology. The objective of this research study is to identify and systematically evaluate the determinants of CBS development adoption and OSS development adoption in global software development organizations. We developed two conceptual research models based on the innovation characteristics from the diffusion of innovation theory and the technology-organization-environment framework to assess the determinants that influence the adoption of globally distributed CBS development and globally distributed OSS development from an organization perspective. We then developed two questionnaire surveys and collected data from 115 participants in case of CBS development and 198 participants in case of OSS development to test research models hypotheses. In case of globally distributed CBS development, the results show that relative advantage, complexity, technology competence and top management support are statistically significant and are key determinants that influence the adoption of CBS development in global context. Whereas, in case of globally distributed OSS development, the results show that relative advantage, complexity, technology readiness, top management support and competitive pressure are statistically significant and are key determinants that influence the adoption of OSS development in global context. It is anticipated that the assessment of determinants for adopting CBS development and OSS development in global software development organizations provides valuable insight to*

researchers and practitioners for developing strategies to guide implementation of CBS development and OSS development in global software development context.

ABSTRACT (ARABIC)

وعلى مدى العقد الماضي، اعتمد عدد متزايد من مشاريع تطوير البرمجيات الموزعة على الصعيد العالمي لتطوير البرامج القائمة على المكونات نظرا لقدرتها على دمج وإعادة استخدام المكونات في المنتجات الجديدة، وتطوير برمجيات المصدر المفتوح بسبب إمكاناتها لإدخال تحسينات على جودة البرمجيات وتخفيض التكاليف في المشاريع الموزعة عالميا. وعلاوة على ذلك، فإن تطوير شبكة الاعتماد على المكونات الموزعة عالميا هو منهجية واعدة لبناء برامج ذات جودة عالية من حيث التكلفة من خلال تطوير مكونات البرمجيات بشكل متواز من قبل فرق عالمية. وبالمثل، فإن تطوير نظام برمجيات المصدر المفتوح الموزع عالميا يمكن من تطوير منتجات البرمجيات من قبل فرق موزعة عالميا على مدار الساعة دون التأثير على جودة الرمز والإنتاجية. ومع بدء المزيد من المنظمات في تطوير الاعتماد على المكونات الموزعة عالميا وتطوير نظام برمجيات المصدر المفتوح الموزع عالميا، من الضروري للباحثين والممارسين تحديد وتقييم المحددات التي تؤثر على المنظمات في اعتماد تطوير كل من النظامين عالميا. والهدف من هذه الدراسة البحثية هو تحديد وتقييم محددات اعتماد لجنة النظم الأساسية واعتماد تنمية خدمات دعم العمليات في المنظمات العالمية لتطوير البرمجيات. وقد وضعنا نموذجين بحثيين يستندان إلى خصائص الابتكار من نشر نظرية الابتكار وإطار التكنولوجيا والتنظيم والبيئة لتقييم المحددات التي تؤثر على اعتماد تطوير الاعتماد على المكونات الموزع عالميا والتوزيع العالمي للتطوير برمجيات المصدر المفتوح من منظور المنظمة. ثم قمنا بتطوير استبيانين وجمعنا بيانات من 115 مشاركا في حالة تطوير الاعتماد على المكونات و198 مشاركا في حالة تطوير برمجيات المصدر المفتوح لاختبار فرضيات نماذج البحث. وفي حالة تطوير الاعتماد على المكونات الموزع عالميا، تظهر النتائج أن الميزة النسبية والتعقيد والكفاءة التقنية والدعم الإداري الأعلى ذات دلالة إحصائية وهي عوامل رئيسية تؤثر على اعتماد تطوير هذا النظام في السياق العالمي. في حين أنه في حالة تطوير نظام برمجيات المصدر المفتوح الموزع عالميا، تظهر النتائج أن الميزة النسبية والتعقيد والاستعداد التكنولوجي ودعم الإدارة العليا والضغط التنافسي ذات دلالة إحصائية وهي محددات رئيسية تؤثر على اعتماد تطوير هذا النظام في السياق العالمي. ومن المتوقع أن يوفر تقييم محددات اعتماد تطوير لجنة النظم الأساسية وتطوير خدمات دعم العمليات في المنظمات العالمية لتطوير البرمجيات رؤية ثاقبة للباحثين والممارسين من أجل وضع استراتيجيات لتوجيه تنفيذ تطوير الاعتماد على المكونات وتطوير برمجيات المصدر المفتوح في سياق تطوير البرمجيات العالمية.

CHAPTER 1

INTRODUCTION

Over the last decade, the widespread use of software has placed new expectations on the software industry [1, 2] and there is an ever growing need for techniques that can enhance software development processes to reduce development costs and produce high quality systems. Among others, few software development methodologies that have gained attention over the last decade are Component-Based Software (CBS) [2], Open-Source Software (OSS) [3] and Global Software Development (GSD) [4]. CBS development focuses on assembling software components that are either purchased off-the-shelf or developed in-house, to build a software system [5]. Similarly, OSS development focuses on freely accessible OSS source code for software developers to use it for establishing large software systems [6]. On the other hand, GSD is the process where a company (client) contracts all or part of its software development activities to another company (vendor), who provides services in return for financial compensation [7].

Nevertheless, many software organizations have structured their software product development in global software development environment, and meanwhile adopted different software development practices such as Component-Based Software (CBS) development methodology [8, 9] and Open-Source Software (OSS) development methodology [10, 11, 12]. Moreover, the extensive use of software has pushed the software industry towards these software development practices [2, 13, 1]. Generally, a software system is gradually developed with more features and expanded through its new upgraded versions. Software industry has been looking for software development practices that allow software reuse [14]. Software reuse i.e. reuse of components, is an expected advantage of component-based software (CBS) development methodology [15].

Moreover, software reuse has been increased, therefore different advantages are achieved [14, 16]. Many software organizations have structured their product development in globally distributed environment and meanwhile adopted CBS development methodologies [8, 9]. The use of CBS development in globally distributed environment has build software systems with the advantages of better quality, software reuse, and lower development costs by the extensive use of quality components [8, 2, 17]. Moreover, software development organizations have adopted CBS development in GD environment with an additional expectation that this approach may mitigate the problems of coordination and communication in globally distributed teams [18].

Furthermore, software development organizations are also building software systems with OSS development practices, that provide freely available source code [6, 19]. Free available source code, i.e. no license fee, is an expected advantage of open-source software (OSS) development methodology [6]. The source code of OSS system is available publicly and software developers are using it for establishing large software systems [20, 21]. The importance of OSS development is due to its cultural and economical benefits. OSS development has increased the interest of software development organizations from business point-of-view and provide benefits such as reliability, cost savings, reduction in time-to-market, rapid responses to user requests, community contribution, increase in quality software, and fast improvements [22, 23, 24]. The use of OSS practices allow users to utilize the benefits of per-define modules that make a reduction in development time [25]. Moreover, the distribution of globally distributed team members enables the development of software products in round-the-clock (RTC) development without affecting the quality of the code, and productivity [12].

1.1 Problem Statement

Though software development practices and globally distributed environment have a positive outlook, in CBS development approach, organizations have faced many challenges such as the integration of software components that need considerable efforts and produces low quality [26]; long term management of CBS systems

[27]; component selection [28]; requirement satisfaction and interoperability [2, 29]; and challenges imposed by temporal, cultural differences and geographical distance in globally distributed environment [30]. These challenges indicate that not all organizations are interested in adoption of CBS development methodology in GD environment. CBS development is an innovate approach for globally distributed organizations, but these organizations need to either perform software development from scratch or re-engineer their existing software products in order to adopt CBS development in GD environment [31]. Therefore, the disinclination to adopt CBS development in globally distributed environment is noteworthy.

Similarly, in OSS development approach, there are also some significant challenges such as: the establishment of OSS is unlike proprietary software in some areas; participation of the community and coordination of the development process [22]; the estimation of time and cost for understanding, learning, and integrating OSS components [24]. Furthermore, some of other challenges are component selection, component configuration, and long-term management of component-based systems [2, 27, 32], whereas, some of the development challenges are communication, coordination, and culture challenges due to the distribution of globally distributed teams in different geographical locations [33]. However, the OSS development practices are not adopted by software industry altogether, therefore, there exist some organizations that are not interested in globally distributed OSS development adoption. Although, there are problems and challenges in GD

OSS development, but a number of organizations are practicing OSS development methodologies in globally distributed context [11, 12]. Hence, the use of globally distributed software development practices such as CBS development and OSS development allow globally distributed organizations to overcome challenges associated with CBS development and OSS development, and meanwhile have the benefits of globally distributed environment [12, 11, 18, 34]. Therefore, it is important for practitioners to identify the determinants that influence globally distributed organizations to adopt globally distributed CBS development and globally distributed OSS development.

1.2 Motivation

Despite the problems and challenges experienced with GD-CBS development and GD-OSS development approaches, a large number of organizations are practicing CBS development methodologies and OSS development methodologies for software systems development in globally distributed environment [9, 8, 35, 11, 12]. This thesis work consider the adoption of CBS development and OSS development in globally distributed environment; and the objective of our research work is to identify the determinants that influence globally distributed organizations to adopt CBS development and OSS development in a global context. Some research studies on CBS development adoption have focused on architectural aspects [32], the impact of subcultural inconsistencies [35], the use of analytic hierarchy process [32]. A few research studies on GD-CBS development adoption have focused on management of GD CBSD projects [36, 18, 37, 38, 31, 8]. No study has worked on assessing the direct effects and indirect effects of the determinants on CBS development adoption in GD environment. This gives a motivation to our study for establishing an integrative conceptual research model. The research model combines diffusion of innovation (DOI) theory [39] for the innovation characteristics of CBS development and technology-organization-environment (TOE) framework [40] i.e. technological-organizational-environmental perspectives for causing its adoption.

Nevertheless, researchers are contributing to the body of scientific knowledge through innovation diffusion and adoption studies. Research studies on OSS development adoption have focused on some categories: OSS communities; OSS development and maintenance; diffusion and adoption of OSS; and characteristics of OSS [11, 41]. Similarly, some other research studies have focused on globally distributed adoption of OSS development [12, 24, 10, 33, 42, 43]. However, the investigation of determinants, which cause the adoption of OSS development in organizations, is addressed by a very few number of research studies [44, 25, 45, 46, 24]. Though, this research work also considers the adoption of OSS development in GD environment and aims to identify the determinants that influence organizations to adopt OSS development, therefore, it is also design to empirically assess the effects of determinants of the integrative research model (i.e. a combination of DOI theory and TOE framework) through PLS-SEM (partial least squares - structural equation modeling) [47]. Furthermore, this research study has been designed to narrow the gap between GD CBS development and GD OSS development's research and practice in such a way that it is accessible to both researchers and practitioners.

1.3 Objectives

Software organizations have migrated towards globally distributed software development approach due to low cost and good quality of software products [48, 49]. Meanwhile, they are using CBS development and OSS development methodologies in globally distributed environment [34]. The main objective of this research work is to identify and evaluate the effects of the determinants that influence globally distributed organizations to adopt CBS development and OSS development in global context.

The objectives, in case of GD CBS development adoption, are as follows:

- To identify the determinants of GD CBS development adoption in globally distributed context.
- To evaluate direct effects and indirect effects of determinants on the adoption of GD CBS development in globally distributed context. In order to address these research objectives, we have designed the following research questions.

  RQ1: What are the determinants that influence the adoption of globally distributed CBS development in GD organizations?

RQ2: What are the direct and indirect effects of the determinants that influences globally distributed organizations to adopt GD CBS development methodology in global context?

The objectives, in case of GD OSS development adoption, are as follows:

- To identify the determinants of GD OSS development practices adoption in globally distributed context.
- To evaluate direct effects and indirect effects of determinants on the adoption of GD OSS development in globally distributed context. In order to address these research objectives, we have designed the following research questions.

  RQ3: What are the determinants that influence the adoption of globally distributed OSS development in GD organizations?

  RQ4: What are the direct and indirect effects of the determinants that influences globally distributed organizations to adopt GD OSS development methodology in global context?

These objectives will help organizations in better understanding the determinants of CBS development practice adoption and OSS development practice adoptions in globally distributed environment and its relative advantages. Our contribution of this research study is an investigation of the effects both direct and indirect of the determinants which influenced GD-CBS development and GD-OSS development adoption, through integrative research models. This will provide potential knowledge to other researchers and organizations about the importance of systematically evaluating the determinants of CBS development and OSS development adoption in globally distributed context.

1.4 Deliverables

In this research study, we have provided the following deliverables:

1. Determinants (Factors) that influence the adoption of both CBS development and OSS development in globally distributed environment.

2. Integrative research models based on adoption theories such as DOI theory and TOE framework for both CBS development adoption and OSS development adoption in globally distributed environment.

3. Investigation of the direct and indirect effects the determinants that influence the adoption of both CBS development and OSS development in globally distributed environment.

4. Systematic evaluation of the determinants that influence the adoption of both CBS development and OSS development in globally distributed environment.

5. Research findings in the form of publications.

1.5 Contributions

The aim of this research work is to assist globally distributed organizations in better understanding the determinants that influence organizations to adopt CBS development and OSS development practices in globally distributed environment. Adding to our aim, there does not exist any research study that has worked on evaluating the effects both direct and indirect of the determinants that influenced the adoption of CBS development and OSS development in globally distributed environment. As a motivation, we have established integrative conceptual research models that combine DOI theory and TOE framework [40] for evaluating the effects.

The contribution of this research work is twofold. First, an investigation of the direct and indirect effects of the determinants that influenced GD-CBS development adoption, through the integrated research model. Therefore, the research model is evaluated through the data obtain from 115 participants. This allows us in contributing to the broader area of scientific knowledge where assessment of the determinants for globally distributed CBS development adoption was not studied so far. Second, we have contributed through empirically investigating the direct and indirect effects of determinants, which influenced globally distributed OSS development adoption, described in another integrative conceptual research model. For evaluating our research model, we utilized the data obtain from 198 participants of different countries. This also allows us in contributing to the broader area of scientific knowledge where evaluation of the determinants for GD-OSS development adoption was not studied so far. Furthermore, this research work also underlines the significance of evaluating the determinants of globally distributed CBS development and globally distributed OSS development in global context.

1.6 Thesis Organization

In the reminder of this thesis work, we provide a background that shows globally distributed CBS development and globally distributed OSS development along with two theories such as DOI theory and TOE framework. We then show the literature review on the adoption of CBS development and OSS development in globally distributed environment. Next, we present the theoretical foundations for our conceptual research model along with research hypotheses, research methodology, results and discussions for GD CBS development adoption. We then present our another conceptual research model along with proposed hypotheses, research methodology, results and discussions for GD OSS development adoption. At last, the limitations, threat to validity, and future directions of our research study are presented along with conclusions of globally distributed CBS development and globally distributed OSS development adoption.

CHAPTER 2

BACKGROUND

This chapter introduce the concept of Global Software Development (GSD), Component-Based Software (CBS) development, Open-Source Software (OSS) development, GD CBS Development, GD OSS development, diffusion of innovation (DOI) theory, technology-organization-environment (TOE) framework, and the integration of DOI theory and TOE framework.

2.1 Global Software Development (GSD)

In global software development (GSD), software development projects are build in a globally distributed (GD) environment. In GSD, software developers are connected geographically form different locations but work together to achieve development on time. Due to the nature of this approach, different experts can be working remotely. That's why, GSD has contributed to achieve top-level organizational goals [34].

2.1.1 Benefits of GSD

Software industry has turned to build software development projects in global distributed (GD) environment i.e. Global Software Development (GSD); and their expectations of getting more benefits such as low cost, high quality, successful project management, economical profit, and technical benefits from the use of this approach constructed the popularity of GSD [48, 49, 4, 50, 51]. In GSD, software developers are connected geographically form different locations, but work together to achieve development in less time [4], one of the other reasons of its popularity. Due to the nature of this approach, experts can be working remotely. Development tasks are allocated to globally distributed teams, who address these tasks under the supervision of experts available elsewhere in the globe.

Furthermore, GSD has contributed to achieve top-level organizational goals [34] and also approves exceptionally low-cost development projects of client-site organizations in vendor-site organization's countries [52, 49]. Furthermore, client-site organizations get benefits from GSD, in such a way, that they provide their tasks to vendor-site organizations that are working outstandingly in other countries [52, 49]. The use of GSD projects allows offshore vendor-site organizations to improve their service qualities [14]. In other words, offshore vendor-site organizations also get benefits by this approach because of working on the projects of client-site organizations and the service qualities of the offshore vendor-site organizations are improved by implementing GSD projects [14, 9].

2.1.2 Challenges of GSD

Despite the benefits of GD environment, there are also some challenges associated with it. Organizations working on software development practices in GD environment have some challenges such as cultural, temporal, and geographical differences that has affected software development projects in terms of communication, coordination, and control processes [34, 9, 53, 54, 55]. Furthermore, GSD teams has also some challenges such as lack of trust, lack of team awareness, lack of co-ordination, lack of cultural understanding in teams, lack of conflict-management, risk-management, knowledge-management, and knowledge-sharing between sites [30, 56, 57, 58] that affect software development practices in GD environment. However, GSD is not free from challenges and risks, but as a matter of fact, a large number of organizations are involved in the use of this approach and getting benefits out of it [37]. These challenges contribute in raising the question whether or not the use of globally distributed software projects can benefit from other factors such as humans and social aspects [37]. Therefore, software industry has an increasing interest in adopting software development practices in GD environment or multi-sited organizations to decrease the cost for development and increase the quality of their product [56].

2.2 Software Development Practices

2.2.1 Component-based Software (CBS) Development

The use of CBS development allows the development of software components and the use of integrating different commercial off-the-shelf (COTS) software components to create products [17, 1, 59] with the advantages such as better quality of the software, and reduction in development costs by the extensive use of quality components [8, 2, 60]. CBS development is also known for software reuse such as the reuse of components across many products. Moreover, there is also a great opportunity to update existing components with advanced versions of software components in a 'plug-and-play' manner unless there isn't a compatibility issue [38]. Furthermore, there is no match between CBS development approach and traditional waterfall approach, therefore, CBS development approach is totally distinct from the traditional waterfall approach [2].

Though CBS development has a positive outlook, software development teams has been faced many challenges while working with CBS development environment [38, 9], reported in literature. Challenges such as long-term management of component-based systems, development models, requirement management and component selection, interoperability, and component configuration are some of many challenges faced by CBS development today [32, 27, 2]. Some of other risks associated with CBS development are time and efforts. Although, time and effort required for development of reusable components [27, 61] and to bring stability in conflicts between what exists and what's require [29]; have opened door for new risks in CBS development. Despite the benefits of CBS development [2], the CBS development specific challenges can be address [9] by using development guidelines and approaching open architecture to accomplish CBS projects.

2.2.2 Open-source Software (OSS) Development

The use of open source software (OSS) development is changing the processes in the organizations for development, usage, and commercialization of software product: and OSS is a phenomenon that had a significant impact on the software-intensive organizations and industry over the last decade [24, 62] with the advantages such as reduction in cost and minimize 'time-to-market' [63, 64, 10]. OSS development practices allow the use of freely accessible OSS source code for building a software system [6, 19, 3]. This source code is available publicly and software developers are using it for establishing large software systems [20]. However, OSS development is more than just source code and gained importance due to its benefits. A number of OSS systems have gained significant popularity in the market place [45, 65, 66]. Moreover, OSS development allows the organizations to transform from traditional-business models to service-based models by the use of free licenses [67]. Furthermore, OSS development has increased the interest of organizations from business point-of-view and provides benefits such as reliability, low cost and security [22, 68]. Therefore, OSS development approach is significant and totally distinct from traditional software development

[69].

Despite the positive outlook of OSS development, organizations can sometimes acquire bad quality of OSS software while expecting a good one [70]. OSS standards can be used to integrate different products [65], but the challenges regarding the integration process of OSS components into other products are similar to the integration process of proprietary components [13]. There are also some challenges such as: OSS puts barrier for non-technical users, participation of the community, and coordination of the development process; OSS projects are not deadline driven; and the establishment of OSS is unlike proprietary software in some areas [22]. Furthermore, some of the challenges are component selection, component configuration, and long-term management of component-based systems [2, 27, 32]. However, to bring stability in conflicts between what exists and what is require, has opened the floor for new risks [29]. If organizations carefully address their requirements with respect to OSS, then these challenges and risks can be overcome [13].

2.3 Globally Distributed Software Development Practices

2.3.1 GD CBS Development Practice

Software development industry has followed the trend of using component-based architectures for the distribution of software development activities over different sites available on different geographical locations [36]. Many software organizations have structured their product development in GSD environment and meanwhile adopted CBS development methodologies [8]. Although, there are problems and risks in globally distributed CBS development projects, but organizations at a continually increasing rate are adopting CBS development methodologies in projects, developed in globally distributed environment [8, 9]. Software organizations have overlooked the risks and problems involved in GD CBS development projects and started adopting CBS development architectures in their projects [8, 38].

Software development teams in globally distributed environment have adopted CBS development and created some expectation regarding the mitigation of coordination breakdowns encountered in traditional (non-CB) GD software development [38, 18]. Globally distributed teams can try to understand CBS development's issue in order to have successful software development projects [71, 8]. Though GD CBS development has a positive outlook, GD software development teams has been faced many challenges while working with CBS development environment in GD [38, 9, 18, 8], reported in literature. If GD teams look after and understand CBS development's management issues, then successful software development projects will be accomplished and good relationships between client-site organizations and vendor-site organizations will be conserved [71, 8].

2.3.2 GD OSS Development Practice

Software industry has been developing and maintaining software products as open-source software (OSS) by a group of teams available over different sites of the organization in different geographical locations throughout the world [12, 24, 36, 42]. Therefore, the distribution of these globally distributed team members enables the development of software products in round-the-clock manner i.e. round-the-clock development without effecting the quality of the code, and productivity [12]. Conflict in software development is inevitable and it is a fundamental part of collaborative work settings [72] such as working in a globally distributed environment. As a matter of course, when virtual (i.e. OSS) communities make use of strong organizational cultural beliefs to hold these distributed teams together, then the mitigation and resolution of conflict is not much complicated [43].

OSS is also known as open collaboration [73] and it is easier than proprietary software. Moreover, a number of software organizations have structured their software product development in GD environment and meanwhile adopted OSS development methodologies [12, 24, 10, 33]. Organizations prefer to use OSS due to control, security, training, quality, stabilizability, flexibility, audit-ability, freedom, and support options [74]. After all, the use of OSS development provides essential support for enormous concurrent development through modularized architecture and standardized IT platform [33], which is advantageous for GD OSS development teams as they intend to work in geographically different locations [75].

Aside from the positive outlook of OSS development communities in GD environment: there exists some challenges in development of GD systems, for example, communication, coordination, and culture challenges due to the distribution of GD teams in different geographical locations; and some challenges regarding the deployment of GD systems, for example, organizations need to accommodate the local exigencies of the distributed sites that are working on different activities in a global environment [33]. Moreover, the unavailability of improvised communication between GD OSS development teams produced a decrease in collaboration and coordination between GD sites working in geographically different locations [76, 42]. If GD OSS development communities look after and understand OSS development's management issues, then successful software development projects will be accomplished and good relationships will be conserved [43, 33]. However, there are problems and risks in globally distributed OSS development projects, but organizations at a continually increasing rate are adopting OSS development methodologies in projects, developed in globally distributed environment [42, 12, 13, 24].

2.4 Adoption Models

The innovation diffusion and adoption studies have frequently used many theories such as the diffusion of innovation (DOI) theory [77], the theory of planned behavior (TPB) [78], the technology acceptance model (TAM) [79], technology-organization-environment (TOE) framework [40], and the unified theory of acceptance and use of technology (UTAUT) [80]. Two of these theories such as DOI theory [77] and TOE framework [40] is in the scope of this research study. Whereas, the other theories are not examined in this research study because they are applicable to an individual's choice. Therefore, two integrative conceptual research models of the respective two theories such as DOI theory and TOE framework are constructed for the adoption of each innovation such as CBS development and OSS development in global context.

2.4.1 DOI Theory

Information Systems (IS) research has commonly used DOI theory [77] as an adoption theory. It has five attributes that helps an organization to either adopt or ignore an innovation [81, 82, 46, 83, 84, 85]. These attributes are: first attribute is relative advantage, which is an innovation's degree of attractiveness to the organization, and is used to show the perceived organizational benefits of the new innovation in comparison to the existing innovations of the target organization; second attribute is compatibility, which is an innovation's degree of flexibility to the organization's ongoing requirements, and integration with the target organization's existing practices, processes and IT infrastructure; third attribute is complexity, which is an innovation's degree of complication to the organization's operational use and operations; fourth attribute is observability, which is an innovation's degree of visibility and understanding to the members of adopting organization; fifth attribute is trialability, which is an innovation's degree of simplicity in terms of experiments with the innovation in the organization [86, 83, 84].

Generally, DOI is based on the features of the innovation and what people understand about the adopted technology. An innovation in a system is like a communication process that uses different channels [39]. Moreover, other three important factors that influence organizations for the adoption of an emerging innovation are: internal organizational structure (i.e. number of employees and interconnectedness); external characteristics (i.e. system openness); and individual (i.e. change commitment by leadership attitude) [86, 87], which is not as complex entity as an organization, and is an important factor for adopting an innovation by an organization [86, 87]. Therefore, DOI theory based on the perception of people regarding the adoption of an innovation [77].

The use of DOI theory [77] also involves a five-stages process in which a new innovation is processed for the adoption in an organization [88]. These stages are: first, knowledge stage, which reveals information about the new adopting innovation; second, persuasion stage, which shows the interest level of the organization in adopting an emerging innovation; third, decision stage, which decides either to accept or reject the adoption of an innovation; fourth, implementation stage, which presents the practicality and effectiveness of the new innovation; fifth and last, confirmation stage, which describes the reinforcement of the new innovation [88, 89]. Most innovation diffusion and adoption studies have focused on three stages such as persuasion stage i.e. intention, decision stage i.e. adoption, and implementation stage i.e. routinization [90, 91]. The focus of this research work is on decision stage i.e. adoption, whereas a future research study could be focusing on three stages such as persuasion stage, decision stage, and implementation stage.

2.4.2 TOE Framework

The TOE framework is used to allow an organization to understand the procedure of adopting an innovation from its organizational point-of-view [40]. Similar to other diffusion theories, TOE framework recommends three attributes such as technological context, organizational context, and environmental context that assist an organization to adopt a new innovation. First attribute is technology context, which describes the current technological attributes, abilities, characteristics, capabilities, practices, infrastructure, essential qualities and standards that are internally available as well as describes the availability of external relevant technologies for the adoption of new emerging innovations or technology of interest in the host organization; second attribute is organization context, which contains significant resources and is used to understand the characteristics that will help in adopting and implementing an innovation by the host organization; third and last attribute is environmental context, which is used to understand the market place in terms of opportunities and limitations before adopting a new innovation so that the host organization knows about the nature of target market, market elements, regulators, and competitors [92, 93, 87, 40, 94].

In other words, technological context is used to understand the technological capabilities and qualities of an innovation towards the host organization. Organizational context is used to understand the characteristics that will help in adopting an innovation by the host organization. Lastly, environmental context is used to understand the market place before adopting a new innovation so that the host organization know about its competitors. Moreover, particular human resources and structural aspects are described in technological characteristics of an organization [86], whereas, environmental context looks for competitors and nature of the market and from a product-production point-of-view, approach to other market resources as well as keep enough interactions with government [93].

For many of the adoption studies, the role of TOE framework [40] is to explain the effects of determinants that are used in the adoption of innovations, such studies are Open Source platform adoption [46], adoption of open systems [95], e-business use [96], internet and e-business adoption [84], adoption of open source software [24], e-business usage [97], adoption of the Internet [81], cloud computing adoption [86], RFID adoption study [98], Effective benchmarking adoption [82], and open source adoption [25].

Despite the fact that TOE framework is used in different adoption studies, it is neither extensive nor considers other important determinants [89] such as development cost and cost savings that are critical to an organization when adopting a new innovation i.e. GD-CBS development and GD-OSS development in the case of our research work [44, 13, 24, 45]. This is one of the other limitations which encourages researchers to understand the adoption of technological innovation through establishing integrative research model of more than one theoretical perspectives i.e. the integration of DOI theory with TOE framework [86, 89].

2.4.3 Integrating DOI and TOE

The theoretical concept for understanding the adoption of IT innovations has been build through an integration process of more than one theoretical approaches by a number of considerable researchers [99, 100, 87, 101, 86]. Two things need to be better understand regarding the adoption of new emerging IT innovations from organizational decisions point-of-view; first, a comprehensive context of the study; second, particular variables for specific innovations [95]. IT adoption studies have considerably used the integration of DOI theory and TOE framework, and this integration is blessed by the support of empirical studies [102, 83, 82]. These both theories share different attributes with each other in many ways. Furthermore, empirical studies have evidenced the integrative use of DOI theory and TOE framework [86, 102, 82, 89], for identifying the determinants i.e. particular factors for the adoption of IT innovations. Although, Information Systems (IS) research has recognized DOI theory as an adoption model [81, 85], but the technological perspectives of TOE framework has been integrated with DOI theory to strengthen the innovation characteristics of DOI theory [87, 103, 95].

Even though, sometimes, the IS research has used these two theories separately, but there are some similarities and differences in them. The technological context of TOE framework gives tacitly the similar idea as that innovation characteristics of the DOI theory [40, 39, 46]. Whereas, the organizational context of TOE framework contains similar measures as the internal and external organizational characteristics of DOI theory [103]. Although, there exist similarities between both of these theories, but there are also many differences between these two approaches in some circumstances. In TOE framework, it does not provide any suggestion for some innovation characteristics such as complexity [84], observability [86], compatibility [83], trialability [86], individual (change commitment by leadership attitude) [87] etc. Whereas, in DOI theory, it does not address the role of some innovation characteristics such as technology readiness [93], application functionality [86], technology competence [83, 81], availability of alternatives [87], top management support [84], firm size [96], degree of centralization [46], organizational readiness [93], competitive pressure [86], regulatory support [96, 87] etc. Therefore, their integrative model helps to cover up the shortcomings of each other and helps to provide a comprehensive look to the organization about adopting an innovation.

In addition to creating integrative conceptual research models, the researcher obtain evidence for particular constructs of the research models from the published literature. The researcher targeted two theories such as the DOI theory [77] and the TOE framework [40] for conducting the determinants when adopting an innovation. Most-cited studies are grouped together to find out measurement items (for constructs) that have been taken for evaluation process in the literature on adoption of innovations. Therefore, this process helped the researcher in finding out the appropriate measurement items and its relevance to CBS development and OSS development adoption. At last, the summary of this approach for determining appropriate constructs is summarized in *Table 2.1* along with its corresponding dependent variables.

Table 2.1: Constructs for Research Models in peer reviewed journals.

Study	Year	Theory	Innovation/technology	Constructs										
				a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.
[104]	2017	DOI and TOE	Cloud computing adoption	X	X	X					X	X	X	
[105]	2017	DOI and TOE	Mobile applications adoption	X	X	X					X		X	X
[106]	2017	DOI and TOE	E-pubic procurement adoption	X								X	X	
[107]	2017	DOI and TOE	Cloud service certifications adoption	X	X	X	X		X		X		X	
[108]	2016	DOI and TOE	Green IT adoption									X	X	
[89]	2016	DOI and TOE	Adoption of SaaS	X	X	X	X		X		X		X	
[86]	2014	DOI and TOE	Cloud computing adoption	X	X	X	X	X			X		X	
[84]	2011	DOI and TOE	Internet and E-business adoption	X	X	X					X	X	X	
[102]	2011	DOI and TOE	Cloud computing adoption	X	X	X		X					X	
[87]	2010	DOI and TOE	Information technology adoption			X				X				X
[93]	2010	TOE and others	E-business adoption					X				X	X	
[82]	2010	DOI and TOE	Effective benchmarking adoption	X	X	X			X	X		X		X
[109]	2009	DOI and TOE	Adoption of enterprise systems	X	X	X					X	X	X	
[81]	2009	DOI and TOE	Adoption of the Internet				X		X		X			
[110]	2009	DOI and TOE	Adoption of c-commerce	X	X	X					X		X	
[83]	2006	DOI and TOE	E-business use	X	X	X	X		X				X	
[111]	2012	DOI	Electronic purchasing applications		X					X				
[112]	2010	DOI	Intention to RFID adoption	X			X				X	X		
[113]	2017	TOE	Information technology adoption		X		X		X		X		X	
[114]	2017	TOE	E-health adoption								X	X		
[115]	2016	TOE	Mobile reservation system adoption	X	X				X		X		X	
[44]	2012	TOE	Adoption of Open-source Software	X			X							
[98]	2011	TOE	RFID adoption study			X	X				X		X	
[116]	2011	TOE	Adoption of E-commerce	X			X						X	X
[117]	2008	TOE	E-business adoption									X	X	
[46]	2004	TOE	Open Source platform adoption	X	X		X		X	X				X

Note: a. Relative Advantage; b. Compatibility; c. Complexity; d. Cost Savings; e. Technology Readiness; f. Technology Competence; g. Availability of Alternatives; h. Top Management Support; i. Organizational Readiness; j. Competitive Pressure; k. Technical Support Service.

In the case of DOI, the researcher looked for the innovation characteristics and has selected three innovation characteristics that are most relevant and applicable to CBS development and OSS development adoption. These three attributes such as relative advantage, compatibility, and complexity are applicable to CBS development and OSS development adoption. Whereas, the other two innovation characteristics of DOI such as observability and trialability were not selected due to the fact that they are uncommonly used in adoption studies [110] and are inapplicable to CBS development and OSS development adoption. Therefore, we followed the common guidance of Information Systems (IS) research and excluded both of these attributes of DOI that are not applicable to CBS development and OSS development adoption. Generally, relative advantage is influence and determine by the nature of the innovation being adopted and it can indicate economical growth [77].

Therefore, in case of DOI and CBS development adoption, we proposed that CBS development may provide economical advantage of development cost [8, 38]. But on the other hand, integration cost may decrease the relative advantage of CBS development. Therefore, we introduce two latent variables (constructs) such as development cost and integration cost under the relative advantage of CBS development. Furthermore, in case of TOE and CBS development adoption, properties specific to technology context are technology readiness, technology competence, and availability of alternatives. The organizational context determines the descriptive characteristics such as top management support and organizational readiness. Whereas, the environmental context finds out the competitors and nature of the market by using competitive pressure. These all properties (constructs) are essential for an organization's decision regarding the adoption of a technology (such as CBS development).

Similarly, in the case of DOI and OSS development adoption: time investment is reduce by enabling available skills in the organization [44]; cost savings is gain by the use of free licenses for the OSS software products [13]. Therefore, we have introduced two other constructs such as time saving and cost savings under the relative advantage of OSS development. Other than this, in case of TOE and OSS development adoption: technology readiness is taken under technological context; top management support and organizational readiness is taken under organizational context; competitive pressure and relevant technology support is taken under environmental context. These constructs (i.e. coming from TOE framework) are significant from an organizational decision's point-of-view for adopting a new emerging technology.

The research studies summarized in *Table 2.1* show that over the last decades researchers have used adoption theories such as DOI Theory and TOE framework for identifying and systematically evaluating the determinants that influence the adoption of innovations in organizations. Some researchers have combined DOI

Theory and TOE framework in order to get the benefits of integration that allow researchers to use constructs available in the opposite theory [105, 104], whereas, some researchers have used these theories individually for understanding the adoption process of an innovation [113, 114]. Some of the determinants from these research studies that are also applicable in our research work show the importance of these determinants for evaluating the adoption process of an innovation in an organization.

CHAPTER 3

RELATED WORK

3.1 GD CBS Development Adoption

Software organizations that use software components for their software development projects are following the practices of component-based software (CBS) development. CBS development allows the use of different commercial off-the-shelf (COTS) software components [17, 1] for the development of software projects. It brings better quality and reduction in the software development costs to the adopting organizations [8, 2]. Some software organizations have adopted CBS development and meanwhile located in different locations of the globe. This allows the organizations to practice on globally distributed (GD) CBS development.

There are many studies that have been published research related to CBS development adoption. Bass et al. [17] has assessed the market for CBS development. Their study examined the practices of CBS development from business and technical perspectives. They described that commercial industry has been adopted the practices of CBS development and explained the reasons, factors, and perceived benefits of its adoption. They presented that excellent performance of programmer, flexibility in software systems, flexibility for changes, reduction in time cost, and scalability in software systems are the reasons for adopting such practices in the software industry.

Moreover, Markus Lumpe [118] has developed a framework about modeling and reasoning of different programming abstractions such as CBS development and open-ended language mechanisms. Whereas, Lionel Seinturier et al. [119] has presented a framework that shows the engineering part of CB systems. Their approach implements the Fractal model with aspects through their framework, which is the novelty of their approach. Similarly, Reda Kadri et al. [120] has presented an experience report on CBS engineering in small and medium sized firms. They showed how these companies overlooked the benefits of CBS development and how to make them aware of such advantages regarding this technology. In their perception, the use of CBS development practices can be improve through their report. Moreover, Vincenzo Grassi et al. [121] has been shown a transformation model for the adoption of CB applications. They have focused on the early performance and reliability analysis of CBS practices.

Apart from our discussion on CBS development in the above studies, no study has shown their interest in CBS development in GD environment except Julia's research work [18, 37, 38, 8]. Julia Kotlarsky [18] has researched on CBS development in GD environment. She has focused on the management of globally distributed projects in the organization while having CBS development practices at the same time. The research work of Julia Kotlarsky [18] regarding GD CBS development adoption is noteworthy. She has been shown companies that have adopted CBS development practices in GD environment. She shown that it has been expected that the adoption of CBS development practices may mitigated the problems of coordination and communication in GD context. The difficulties related to the adoption of CBS development are also shown in her studies [18, 37, 38, 8].

This research work consider the adoption of CBS development environment; and the objective of our research work is to identify the determinants that influence organizations to adopt CBS development in a global context. The above few research studies on GD-CBS development adoption have focused on management of GD CBSD projects [36, 18, 37, 38, 31, 8]. Apart from these studies, no research study has performed the assessment of the direct and indirect effects of determinants that cause the adoption of CBS development practices in GD environment. In response to this gap, our research work established an integrative conceptual research model, where DOI theory [39] for the innovation characteristics of CBS development and TOE framework [40] i.e. technological-organizational-environmental perspectives for causing its adoption, are combined.

3.2 GD OSS Development Adoption

OSS is a computer application that has its freely available source code along with a license. This allows an individual to distribute, change and study the software. It can either be developed individually or in a collaborative manner. It is also known as open collaboration [73]. It is easier than proprietary software. The use of OSS development approach allow companies to provide reliability, and high quality of software in an inexpensive manner [122]. It is also known for flexibility and its quickness. The reliability of OSS is due the involvement of large participants for testing and fixing bugs. It gains its speed due to personal goals, corporate objectives, and divergent perspectives [74]. People prefer to use OSS development practices due to control, security, training, quality, stabilizability, flexibility, audit-ability, freedom, and support options. Even though a lot of studies exist in the literature that have presented the development trends of OSS development, some of these studies have been published research related to OSS development adoption [123, 45, 24, 44].

Tomasz and Krystyna [45] have investigated the adoption of OSS development in Poland. They have used TOE framework for their research model. An empirical evaluation is performed over 178 responses from the companies and public institutions. Moreover, they considered four factors such as benefits, costs, environment, and organization that will influence the adoption of OSS development in organizations. Whereas, our research study also include these four constructs. As a result, they have found that perceived benefits and environment are the factors that influence the organizations to adopt OSS development practices. Furthermore, they have created two models, i.e. server application model and desktop application model, for OSS adoption. Lastly, for statistical analysis, they have used smartPLS software that is in the scope of our research, too. Likewise, Jean-Paul and Mark [44] have conducted a research study on the adoption of OSS development in South Africa by using TOE framework. Their work includes a large South African organization that were practicing OSS development approach. Moreover, they have determined that the factors of technological, organizational, and environmental perspective contribute in the adoption of OSS development, which is similar to the case in our research study. However, their work did not consider any statistical investigation.

Similarly, Eugene Glynn et al. [41] has presented the commercial adoption of OSS development through their empirical study. The objective of their study was to investigate the motivation behind the OSS development adoption. This helped them in finding the factors that influenced the organizations to adopt OSS development practices. Their study includes factors such as external environment, organizational context, technological context and individual factors, which is similar to those constructs of our research study. However, their work did not consider any statistical investigation except correlation. Moving on in the literature of OSS development adoption, Samuel and Di Wu [25] have presented the effects of OSS component reuse through the results of their empirical study. Cost, quality, and productivity are taken as an economic factors in their study. The targeted companies in the study were located in Canada and the US. At last, they concluded that if organizations are adopting OSS development practices then they are likely to achieve good quality and more productivity in the software development.

Similarly, Hauge et al. [123] has investigated the adoption of OSS development in Norwegian software industry. The results show that organizations are interested in the use of OSS components rather than the development of its components. They suggested that if OSS is integrated with other practices then the adoption of OSS will be at large scale. As a matter of fact, organizations have adopted OSS development practices but no study has provided evidence to the adoption of OSS development in GD environment. One reason can be this, OSS development by default comes in globally distributed environment [12]. Apart from these above studies, no research study has investigated the determinants that cause the adoption of OSS development practices in GD environment.

The assessment of factors that cause the adoption of OSS development in organizations, is addressed by a very few number of above research studies

[44, 25, 45, 46, 24]. However, the approach for investigation in our research work is twofold: first, our research work considered the adoption of OSS development in globally distributed context; second, our research work aimed to identify the determinants that influence organizations to adopt globally distributed OSS development methodology, therefore, it is also design to empirically assess the effects of determinants of the integrative research model (i.e. a combination of DOI theory and TOE framework) through PLS-SEM (partial least squares - structural equation modeling) [47]. Nevertheless, our research work has been designed to narrow the gap between globally distributed OSS development methodology's research and practice in such a way that it is accessible to both researchers and practitioners.

CHAPTER 4

GD CBS DEVELOPMENT ADOPTION

Globally distributed CBS development has introduced almost endless possibilities of recombining and reusing components for the development of new products in globally distributed organizations [38]. The main objective of this research study is to identify and evaluate the determinants that influence globally distributed organizations to adopt globally distributed CBS development methodology in a global context. The objectives in detail are as follows: (1) to identify the determinants that influence the adoption of globally distributed CBS development in GD organizations; (2) to systematically evaluate the direct and indirect effects of determinants that influences globally distributed CBS development adoption in GD organizations. These objectives will help globally distributed software development organizations in better understanding the determinants of GD CBS development adoption and its relative advantages. To do this, we have addressed the following research questions:

- RQ1: What are the determinants that influence the adoption of globally distributed CBS development in GD organizations?

- RQ2: What are the direct and indirect effects of the determinants that influences globally distributed organizations to adopt GD CBS development methodology in global context?

In order to address the research questions in hand, we start by developing an integrative research model that combines DOI Theory [77] for the innovation characteristics and TOE framework [40] for causing its adoption. The aim of integrating these two theories is to show the diffusion of IT innovations in a holistic manner from globally distributed context point-of-view. The integration of DOI theory and TOE framework enriches the capability of the research model for explaining IT adoptions [103], reported in the Information Systems (IS) literature. Thus, in this research study, the influence of globally distributed CBS development diffusion in globally distributed organizations is shown through technological, organizational, and environmental factors of the TOE framework [40] and through innovations characteristics of the DOI theory [77].

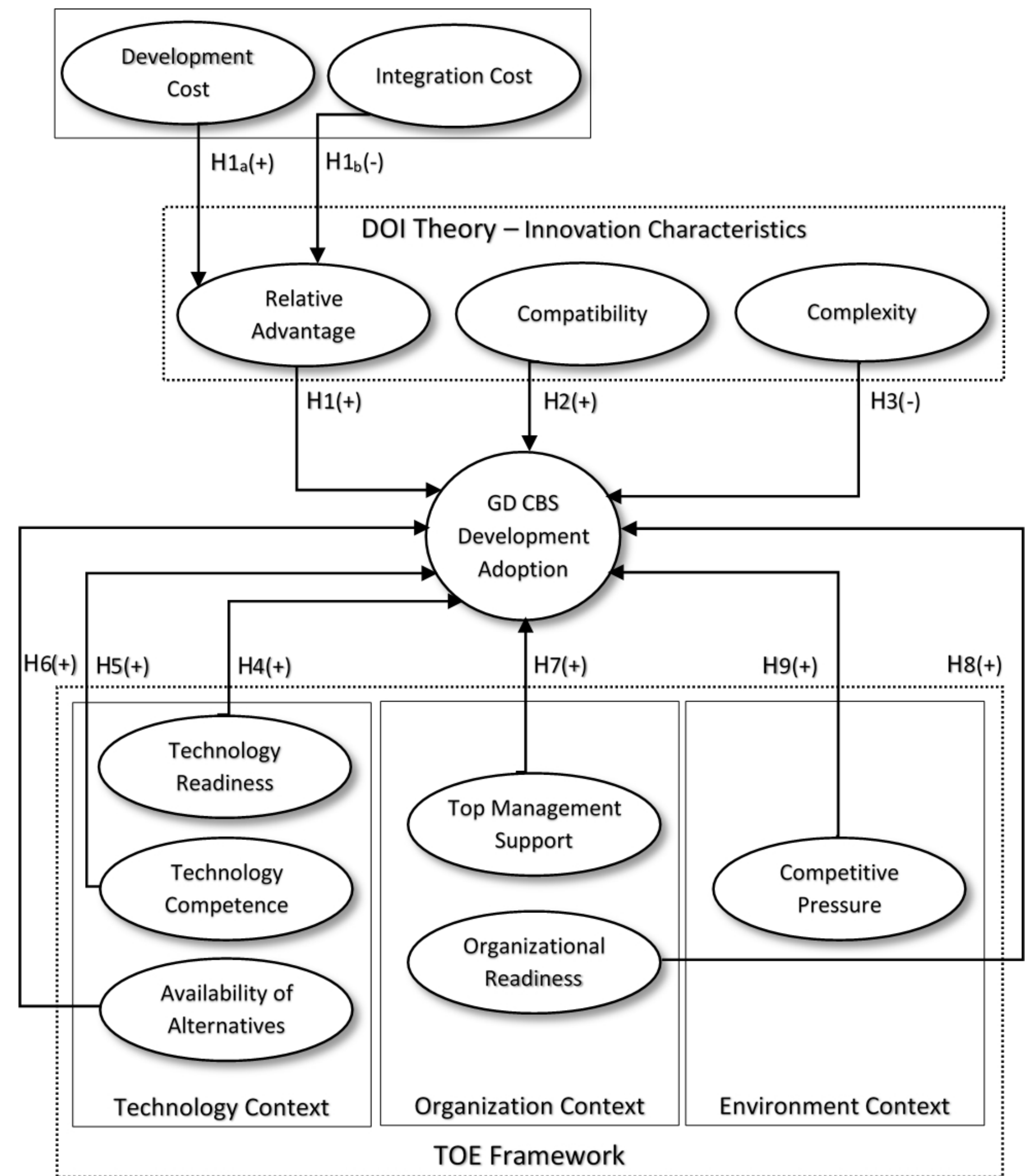

Figure 4.1: Research Model for Globally Distributed CBS Development Adoption

4.1 Research Model and Hypotheses

The published Information Systems (IS) literature on innovation diffusion at organizational level help us to obtain the determinants of the adoption theories for our integrative research model as shown in *Fig. 4.1.* The DOI theory shares some determinants such as relative advantage, complexity, and compatibility that are important for an innovation diffusion. Furthermore, we proposed that globally distributed CBS development may provide economical advantage of development cost [8, 38] and on the other hand, integration cost may decrease the relative advantage of globally distributed CBS development. Therefore, we introduced two measurement items (constructs) such as development cost and integration cost under the relative advantage of globally distributed CBS development. Nevertheless, in case of TOE contexts for GD CBS development adoption, the properties specific to technology context are technology readiness, technology competence, and availability of alternatives. The organizational context determines the descriptive characteristics such as top management support and organizational readiness. Whereas, the environmental context finds out the competitors and nature of the market by using competitive pressure. These all attributes (constructs) are essential for an organization's decision regarding the adoption of a technology such as globally distributed CBS development.

4.1.1 DOI Theory Hypotheses

Relative advantage is an innovations degree of attractiveness to the organization over other existing innovations being used in the organization [39]. With the passage of time, organizations adopt innovations that are comprehensible and easy to perceive. The rationale and motivation for adoption of such innovations is due to its success in creating effective strategies and operational fruitfulness (e.g. reducing development cost) [124]. In the case of globally distributed CBS development, it enhanced the benefits for the organizations than the existing practices in the organizations were providing [38]. Therefore,

H1. Relative advantage positively influences CBS development adoption in GD environment.

Software development cost from estimation point-of-view, refers to the number of people working on development of a software product and time required to complete the software product with respect to overall project plan [125]. In case of developing a similar portion of product on different sites in global environment, both employees and time is ruined and wasted. It is very difficult to gain the knowledge about development cost of a product because of the unclear understanding of product requirements, less detailed specification about the design, problems in project management, and re-engineering of certain portion due to errors [125]. By using CBS development in GD context, development costs can be reduced greatly and there is an exceptional possibility to reuse components, too [8]. Moreover, agility in design and fast-development to approve assurance of shorter time-to-market can be achieved by adopting CBS development in global environment [31]. Therefore,

H1a. Development cost positively influences CBS development adoption in GD environment.

A commercial-of-the-shelf (COTS) product is known for its benefits as well as for some of its integration problems specifically in the case of software components integration, and estimating integration cost will provide a supervision on the use of a COTS situation [26]. It is indeed necessary for the employees of the firm to have experience in off-the-shelf (OTS) software reuse, because inadequate expertise in integration of OTS software system will produce hurdles to gain software component reuse goals [28]. In case of global distributed environment, CBS development needs considerable efforts of the employees to manage components [18], and integrate them effectively. Thus,

H1b. Integration cost negatively influences CBS development adoption in GD environment.

Compatibility is an innovations degree of flexibility to the organizations existing processes, practices and ongoing requirements [39]. Compatibility is one of the significant innovation characteristics for organizations who are looking for new technologies to adopt [82, 46, 126, 127]. Tools and methods are standardize across locations in the case of GD CBS development, moreover CBS development ensures compatibility of documents and components developed and operated geographically at different locations [38]. Therefore, this significant factor (i.e. compatibility) will decide about the embracement of CBS development in global environment. Hence,

H2. Compatibility positively influences CBS development adoption in GD environment.

Complexity is an innovations degree of intricacy and entanglement to the organizations use and operations [39]. With the modern era, organizations are looking for new technologies and innovations with easy-to-adopt approach. If an innovation is hard to understand and operate, than there is a great chance to abandon it [86]. A new challenge in GD CBS development is the dissimilarities in specialization domains and distinctness in technical expertises level developed in each site [38]. Inter-dependency between components is another challenge where ready-made software components, which most of the time are developed independently, are put into integration process and they result in an inexpressive way of synchronization to meet system-to-be requirements [9]. Therefore,

H3. Complexity negatively influences CBS development adoption in GD environment.

4.1.2 TOE Framework Hypotheses

The technology context

An organizations technology context is the technological capabilities, features, attributes and/or essential qualities of the host organization for adopting a new emerging technology or innovation of interest. Technological characteristics of an organization includes particular human resources and structural regards [86]. These structural aspects refer to infrastructure of the technology such as services within the enterprise, that CBS development can replace by pre-fabricated components [18]. Globally distributed CBS development needs no huge changes in the infrastructure of the organization [9]. Whereas, particular human resources are the special people geographically available in different locations who have the understanding and knowledge to implement and integrate components [128]. These two technological attributes are very important for the enhancement of technological readiness of an enterprise. Moreover, organizations with a standard level of technology readiness are more likely to adopt CBS development. So,

H4. Technology readiness positively influences CBS development adoption in GD environment.

Technological capabilities of an organization [38] to accomplish something efficiently and successfully is technology competence, and it is an innovations degree of skillfulness to the organizations investments [81]. Technology competence of the enterprise is consider as an important determinant for the study of information systems innovation diffusion [96, 83] and also reveals about IT human resources such as IT employee or professionals, IT infrastructure items and distributed computing [96]. Due to the nature of CBS development from reusable component point-of-view, companies reduces development cost and do not need to invest again, moreover GD CBS development can benefit competitive advantage in market place [31]. Business component or human (i.e. IT professional) has an essential influence on the success of a product in GD CBS development [8]. Thats why, organizations with high level of technology competence are prior to adopt CBS development. Thus,

H5. Technology competence positively influences CBS development adoption in GD environment.

In technological context of TOE framework, availability of alternative gives a positive direction and standing to an organization for adopting an emerging technology [87]. If the technological characteristics of an innovation are open to the use of other available alternatives, than this technology is more beneficial and advantageous for the adoption of the organization [82]. In the global distributed component-based software development context, components are operated independently in remote locations without inter-site coordination and communication issues, and moreover each site can hold a particular component without an ownership issue [8]. Due to standardizing some particular components and processes specifically for reuse will give clear understanding to work on them across remote sites, independently [18]. CBS development, being an IT innovation, gives a great freedom of using available standard components as alternatives to the adopted environment such as global context in this case. Therefore,

H6. Availability of alternatives positively influences CBS development adoption in GD environment.

The organization context

Different attributes within the organization that have the potential to facilitate or restrict technologies create this context [129], which supports communication and cooperation between team members globally distributed in remote locations. The organization context contains all the important resources and characteristics that help in adopting and implementing an innovation in an environment [92]. The correlation between the adoption of an innovation and the organizational context is influence by many factors such as links of information, degree of centralization [82, 46, 86], formal and informal communication [82, 46, 87], power and control distribution, firm size [82, 86, 96, 83], human and slack resources [82, 46, 86, 87], top management support [86, 84], organizational structure [82, 86] and organizational readiness [84, 93]. So from all these descriptive characteristics, two factors are dominant for the adoption of CBS development in GD environment i.e. top management support and organizational readiness.

Top management support is an essential factor for project success and it regulates the re-engineering of processes or components, integration of services and allocation of resources [86] and tasks [128]. Top management will initially look for the advantages of CBS development and will assign the obligatory resources for its adoption. Now, its time to address the importance of the change to the organization members. This will result in implementing the new innovation with its benefits. Otherwise, top management may not influence the members of the firm [86] and fail to address the true benefits of the new innovation. Hence,

H7. Top management support positively influences CBS development adoption in GD environment.

Though organizational readiness is a sub-category of organizational context, but it also refers to the combination of two contexts of TOE framework i.e. the technology context and the organization context [93, 40]. As an organizational-context-construct for change, it also refers to the change commitment by the members of the organization and their shared belief towards implementing a change using an innovation [130], and to the necessity of the available organizational resources for adopting an innovation [84]. For a successful CBS development adoption in GD context, organization need to standardize and manage social ties such as creating and maintaining team environment, building relationships, facilitating interactions, and component management such as designing for reuse, investment in advanced development, facilitating reuse, and managing vendors [18, 8, 37]. CBS development, being an IT innovation, gives an opportunity to standardization of practices and processes by collectively involvement of the employees of the organization. Hence,

H8. Organizational readiness positively influences CBS development adoption in GD environment.

The environmental context

The key to understand the objectives of the firm is to handle the environmental context of it, which is the internal strategies and processes for conducting the firms business. The environmental context looks for the nature of the market, competitors in the market and from a product-production point-of-view, approach to other market resources, and approach to keep enough interactions with government [92]. It is also influence by entrepreneurial culture [86], market structure [82, 87], perceived environmental barriers [86], competitive pressure [82, 86, 96, 83, 84, 93], technical support services [82], regulatory support [82, 86] [87], and relevant technology support [82, 87].

Competitive advantage (i.e. pressure) is a dominant determinant for the adoption of CBS development in global environment and there are many advantages of a CB system from production point-of-view [18]. In the literature of innovation diffusion, competitive pressure has been gained a good name as an essential determinant for IT technology diffusion. From industry competitors point-of-view, it is a pressure and demand observed by the organization [93, 97]. For survival in todays market place, it is indeed a fundamental necessity to adopt change in the form of adopting a new innovation or technology. By adopting CBSD in global environmental context, organizations can benefit and improve operational efficiency and software efficiency such as better quality, shorter time-to-market, better market-visibility and lower development costs [18]. Therefore,

H9. Competitive pressure positively influences CBS development adoption in GD environment.

4.2 Research Methodology

Globally distributed CBS development practice has been adopted by globally distributed organizations, therefore, we have combined two adoption theories such as DOI Theory [39] and TOE framework [40]. These both theories have a list of determinants that researchers and practitioners use for identifying and systematically evaluating the adoption process of an innovation. In order to validate the theoretical determinants, we then searched for most-cited research studies on adoption of CBS development and grouped them together to find out measurement items i.e. indicator variables or values for our determinants. We used the grounded theory-based coding scheme to review the literature and conceptualize the determinants for adopting CBS development in globally distributed environment. We then used these determinants for creating an integrative conceptual research model as shown in *Fig. 4.1* that has innovation characteristics from DOI theory [39] and TOE framework [40]. We hypothesized that some of these determinants will positively relate and others will negatively relate to the adoption of CBS development in global context.

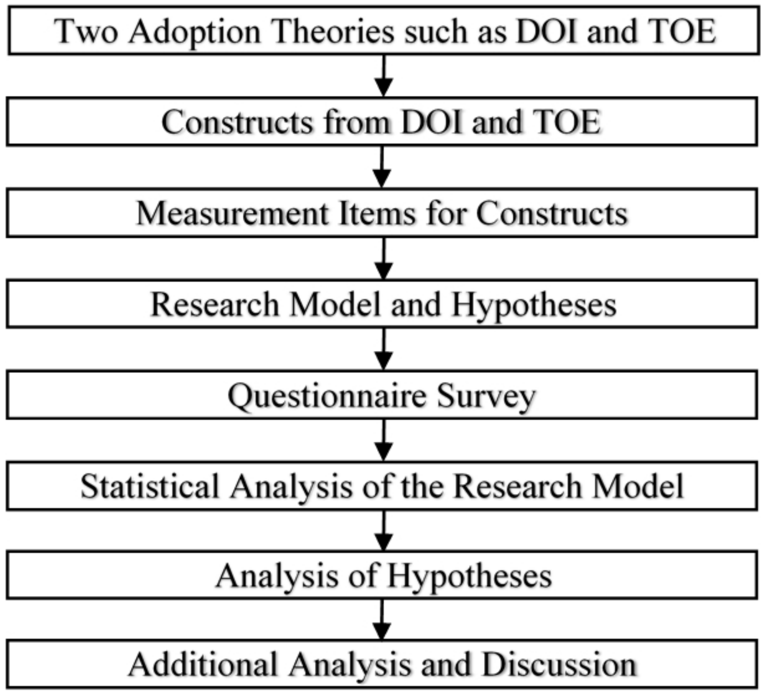

Figure 4.2: GD CBS Development Adoption Methodology

With the help of a questionnaire survey that was created and reviewed by researchers having expertises in Information Systems research, we were able to obtain some data for the statistical analysis of the integrative conceptual research model and for the analysis of our presented hypotheses for the research model. Furthermore, it was important to provide additional information and insights to the researchers and practitioners, therefore, we then provide some qualitative analysis based on the data obtained from our questionnaire survey in order to give more insights to researchers and practitioners. The summary of our research design is shown in *Fig. 4.2.* The integration of adoption theories such as DOI Theory [39] and TOE framework [40] helped us in showing the diffusion of an innovation, i.e. globally distributed CBS development, in a more holistic manner from globally distributed organizations point-of-view. This process helped us in selecting and identifying determinants that have been taken for evaluation process in the literature on adoption of innovations. This also determined the relevance of identified determinants with CBS development adoption in global context.

4.2.1 Measurements

The data collection is performed on the theoretical constructs that influence the CBS development adoption in GD environment described in our integrative research model shown in *Fig 4.1.* Researchers with expertises in Information Systems research, created a questionnaire survey. The questionnaire contributed in assessing the impact of the determinants of CBS development adoption in GD environment. The measurement items for the questionnaire were taken from the published literature. There were three parts in the our survey such that: first, practitioner's details, data collection related to the participant's background; second, demographics, data collection related to the participant's experience and organization's background regarding CBS development in GD environment; third, measurement items, five-point-likert scale was used for collecting data from the values (measurement items) of the construct that ranged from "strongly disagree" to "strongly agree".

Each determinant as shown in *Table 4.3 and Table 4.4* have a minimum of two and a maximum of three measurement items. In the last part of the survey,

Table 4.1: Sample characteristics (N = 115).

Company	Company area	Destination	Size	NP	Respondent's position
1	Software consultancy	Australia	medium	9	IS manager, project manager, senior software engineer
2	Software consultancy	Australia	medium	9	system analyst, team leader, programmer
3	Software consultancy	Australia	medium	9	team leader, project manager, IS manager
4	CBS development house	Australia	medium	9	system analyst, team leader, programmer
5	CBS development house	Australia	medium	8	team leader, project manager, IS manager
6	IT department	Australia	medium	8	senior project manager, senior software engineer
7	CBS development house	Australia	medium	7	IS manager, project manager, senior software engineer
8	CBS development house	Australia	small	5	senior software engineer, project manager
9	IT department	Australia	small	5	team leader, programmer
10	IT department	Asia	medium	10	project manager, software engineer, IS manager
11	IT department	Asia	medium	9	system analyst, team leader, programmer
12	CBS development house	Asia	medium	9	project manager, software engineer, IS manager
13	CBS development house	Asia	small	7	software engineer, team leader
14	IT department	Asia	small	4	team leader, programmer
15	IT department	Asia	small	3	team leader, software engineer
16	Software consultancy	Asia	small	3	senior project manager, senior software engineer
17	CBS development house	Asia	small	1	project manager

Note: Number of Participant (NP).

the respondents were also asked to share their experience regarding factors that affect the CBS adoption in GD environment. To check for a reliable and valid scale used in questionnaire, a pilot study was conducted with 13 participants of 3 organizations. The results determined that the scale is valid as well as reliable. Furthermore, these participants are avoided in the main questionnaire. *Table 4.1* shows the details of our sample (participants).

4.2.2 Data Collection

The subjects i.e. individuals for our survey, who have more than 3 years of experience in the field of software development systems using COTS software components in globally distributed environment, were targeted. The snowball sampling technique [131] has been used for conducting this survey. The researchers then need contact points in target organizations, who would react to our survey seriously and take it noteworthy. People from management level such as project managers were assigned as contact points. These people were aware of all the branches remotely available in different locations and had the access of getting information from multiple sites. Moreover, they were also aware of certain changes such as adopting a new merging technology. A web-based questionnaire was emailed to contact points. The researcher then informed them to forward on to key informants of your organization. In addition, the researchers also tried to determine knowledgeable respondents through"key informants" approach for collecting significant data [132] that will have more meaning as compare to unknowledgeable respondents. The researchers also asked them to report on total respondents frequency of their organizations. As a result, the number of completed questionnaire surveys against its corresponding organizations were recored.

Small-to-medium-sized organizations, allocated in Asia and Australia, were targeted for data collection. These organizations provide custom and CBS development services in GD environment. Staff employed by an organization defines the size of that company. Employees less than 20 means small-sized-company and between 20 to 199 means medium-sized-company. To get an increase in content validity, the researchers specifically mentioned that the respondents either need to have a technical degree i.e. computer science etc, or have enough knowledge to understand CBS development. Check points are asked to determine if the organization has a full time IS professional. Similarly, the position of the participants are ranged from IS managers to software project managers and they are asked for the knowledge regarding CBS development and integration in GD environment.

Data collection was performed in one phase *form 20th-September to 5th-December in the year 2016*. In this phase, 380 participants were contacted. A total of 126 responses were received and manually checked by the researchers until 11 out them were rejected due to incomplete data. As a result, the analysis were performed over 115 remaining valid responses. Response rate of a company

Table 4.2: Mean, Standard Deviation, and Reliability Indicators.

Constructs	Mean	SD	AVE	CR
Development cost	3.83	0.51	0.704	0.824
Integration cost	3.89	0.54	0.734	0.891
Relative advantage	3.79	0.55	0.653	0.849
Compatibility	3.66	0.72	0.698	0.873
Complexity	4.00	0.76	0.584	0.807
Technology readiness	3.64	0.65	0.793	0.919
Technology competence	3.79	0.87	0.677	0.805
Availability of alternatives	3.87	0.66	0.855	0.922
Top management support	3.94	0.59	0.668	0.800
Organizational readiness	3.99	0.61	0.837	0.911
Competitive pressure	3.73	0.50	0.678	0.861
CBS development adoption	3.73	0.37	0.980	0.990

Note: Standard deviation (SD), average variance extracted (AVE), and composite reliability (CR).

is either one (in case of minimum) or ten (in case of maximum). To increase participation rate, we asked the respondents to receive the results of this study, if interested. All the participants are informed about the confidentially of their name and concerned organization name, so that the researcher have an increased in response rate and complete the questionnaire with such understanding.

The determinants from the sample were taken for calculating mean and standard deviation as shown in *Table 4.2*. The survey is conducted in one phase only. An increase in the response rate was gain due to snowballing sampling technique [131]. In total, 30% was the response rate for our survey that is good enough to compare with other studies [96]. Though we had a little number of organizations, 41% (7 companies) were small and 59% (10 companies) were medium organizations. Similarly country-wise responses were recored such as 60% (from Australia) and 40% (from Asia).

4.3 Results and Discussion

To perform statistical analysis on collected data, the integrative conceptual research model as shown in *Fig. 4.1* was empirically evaluated through PLS-SEM (partial least squares-Structural equation modeling) [47]. SEM techniques are known for two different families: the family of variance-based techniques and covariance-based techniques [136]. We, in this research study, performed path modeling analysis through PLS, which is a variance-based technique and only required if the described theoretical model is complex and information is low [136]. The use of PLS estimation requires two conditions to be satisfied: (1) minimum sample size should be 10 times the largest number of indicator variables used to measure one latent variable; or (2) in a structural model, minimum sample size should be 10 times the largest number of structural paths directed at a latent variable [137, 86]. Due to the fact that our sample for globally distributed CBS development adoption has 115 respondents, these two basic conditions for the use of PLS estimation were satisfied. SmartPLS is used for evaluating validity and reliability of the measurement model [47, 137]. Followed by measurement model, we then tested different structural models for globally distributed CBS development adoption in global context.

Table 4.3: Measurement Items for GD CBS Development (Part 1)

Constructs	Items	Adopted Source
Development cost	DC1 – The use of CBSD allows you to reduce the costs involved in developing new products.	[8, 31, 38, 2]
	DC2 – The use of CBSD allows to have a reduction in maintenance cost.	
Integration cost	IC1 – The expertise required to integrate components is usually costly.	[9, 18, 8]
	IC2 – Using CBSD requires more efforts while integrating components.	
	IC3 – With CBSD there is an increase in integration cost over time.	
Relative advantage	RA1 – CB system is easy to use and effective to maintain because of components.	[18, 2, 31]
	RA2 – Using CBSD allows you to reduce process risk.	
	RA3 – The use of CBSD offers standardize components.	
Compatibility	CPT1 – The use of CBSD is compatible with your current development process of the organization.	[38, 58]
	CPT2 – The use of CBSD will reduce the knowledge and information dependencies in the organization.	
	CPT3 – The use of CBSD is compatible with existing applications develop at remote sites.	
Complexity	CX1 – The use of CBSD requires more efforts in finding suitable components.	[2, 18, 9, 8]
	CX2 – The skills needed in integration testing of the product is a challenge in CBSD.	
	CX3 – The adoption of CBSD is not progressive with limited skills for management of components.	
Technology readiness	TR1 – The preparedness of employees who have the knowledge of CBSD.	[18, 9]
	TR2 – The knowledge of the company about how to support development activities by using CBSD.	
	TR3 – The company know the benefits gain by the replacement of existing modules with pre-fabricated components.	
Technology competence	TC1 – For adoption of CBSD, our company have enough human resources and IT infrastructure items.	[9, 8, 18]
	TC2 – Our company's technological capabilities are enough to accomplish IT projects with CBSD.	

Table 4.4: Measurement Items for GD CBS Development (Part 2)

Constructs	Items	Adopted Source
Availability of Alternatives	AA1 – The use of CBSD allows to operate components independently in remote locations.	[18, 8]
	AA2 – The use of CBSD gives a freedom of using available alternative components.	
Top management support	TMS1 – The implementation of CBSD is managed by the firm's management support.	[58, 8]
	TMS2 – For the adoption of CBSD, our companys management is willing to take risks (i.e. financially and organizationally).	
Organizational Readiness	OR1 – Our company has a shared belief towards implementation of a change by using CBSD.	[8, 37]
	OR2 – The skills needed for managing social ties (i.e. interactions, team atmosphere, relationships) and component management is available in the firm.	
Competitive pressure	CP1 – Organization believe that CBSD has an impact on competition.	[31, 8]
	CP2 – For the adoption of CBSD our company is under pressure from competitors.	
	CP3 – CBSD is already being adopted by some of our competitors in the market.	
CBSD adoption	CBSD1 – At what stage of CBSD adoption is your organization currently engaged? Not considering; Currently evaluating (e.g., in a pilot study); Have evaluated, but do not plan to adopt this technology; Have evaluated and plan to adopt this technology; Have already adopted processes, practices or infrastructure of Component-based Software Development.	[98]
	CBSD2 – If you are forecasting that your company will adopt CBSD in the future. How do you think it will happen? Not considering; More than 5 years; Between 2 and 5 years; Between 1 and 2 years; Less that 1year; Have already adopted processes, practices or infrastructure of Component-based Software Development.	

Table 4.5: PLS loadings for GD CBS Development.

Items	Loading	T-statistics	P-Values
DC1	0.713	3.053	0.002
DC2	0.949	8.551	0.000
IC1	0.910	31.855	0.000
IC2	0.725	8.391	0.000
IC3	0.922	35.074	0.000
RA1	0.712	11.813	0.000
RA2	0.816	20.138	0.000
RA3	0.887	31.516	0.000
CPT1	0.927	2.949	0.003
CPT2	0.808	2.955	0.003
CPT3	0.764	2.590	0.010
CX1	0.706	8.753	0.000
CX2	0.757	14.297	0.000
CX3	0.824	16.554	0.000
TR1	0.718	2.667	0.008
TR2	0.961	4.190	0.000
TR3	0.969	4.248	0.000
TC1	0.719	10.675	0.000
TC2	0.915	46.659	0.000
AA1	0.940	58.945	0.000
AA2	0.909	26.521	0.000
TMS1	0.740	9.632	0.000
TMS2	0.888	23.662	0.000
OR1	0.901	22.669	0.000
OR2	0.929	52.266	0.000
CP1	0.728	2.600	0.010
CP2	0.723	2.328	0.020
CP3	0.990	3.715	0.000
CBSD1	0.990	375.871	0.000
CBSD2	0.990	388.966	0.000

Note: All items are based on five-point scale except those noted otherwise.

4.3.1 Measurement Model

The reliability and validity results for our measurement model are shown in *Table 4.2*. Composite reliability (CR) was used to test the reliability of the scales. The CR results for all constructs are greater than 0.7, which confirms the reliability of the scales [136]. The convergent validity was ensured by checking average variance extracted (AVE). As all constructs in the measurement model have an AVE greater than 0.5, thus confirms convergent validity [138]. This indicates that the construct explains more than 50% of the variance of its indicator variables [138]. All measurement items were evaluated for indicator reliability such that they have loading greater than 0.7 and are at significance level 0.01 (except three that are at significance level 0.05) as shown in *Table 4.5*. It means indicator reliability is good, so we retained all measurement items. Moreover, two measures were used for the assessment of discriminant validity of the constructs i.e. Fornell-Larcker criteria and cross-loadings. To confirm Fornell-Larcker criterion, it is required that all the correlations between the latent variables should be less than the square root of AVE of the latent variables [138]. In our case, the correlation between pair of latent variables is less than the square root of AVE as shown in *Table 4.6*, so this criterion is confirmed. To confirm cross-loadings criterion, it is required that all cross-loadings should be less than the loadings of each indicator variable [139]. The resulted cross-loading and loading tables indicate that cross-loadings are less than loadings (tables available on request from the authors of this Thesis), so cross-loadings criterion is confirmed. Hence, these measures confirmed discriminant validity. These all assessments confirms that the latent variables can be used for further evaluations in the research model.

4.3.2 Structural Model

To confirm no concerns of multicollinearity, Variance inflation factors (VIF) is used. The traditional threshold is 5. If the latent variables have VIF less than 5, then it satisfy no multicollinearity. In our case, VIF for most of the latent variables is less than 3 and for some latent variables less than 5, which confirms VIF for suggesting no concern of multicollinearity among latent variables.

Furthermore, standard paths were examined for the analysis of hypotheses of our identified determinants for GD CBS development adoption (RQ1). A bootstrapping method (with 500 re-samples) was used to assess the path significance levels. The resulted path coefficients along with other analysis are summarized in *Table 4.7* (RQ2). The results show that the effect of development cost (β=0.22; $p < 0.05$) on relative advantage is statistically significant (β is the path coefficient). Hence, the hypothesis of development cost as an independent latent variable for relative advantage of GD CBS development (H1a) is confirmed ($p < 0.05$). Similarly, the results also show that the effect of integration cost (β=0.40; $p < 0.01$) on relative advantage is statistically significant. Thus, the hypothesis of integration cost as an independent latent variable for relative advantage of GD CBS development (H1b) is confirmed ($p < 0.01$). To evaluate

Table 4.6: Correlations of the Constructs and AVEs.

Constructs	a	b	c	d	e	f	g	h	i	j	k	l
a. Development Cost	**0.839**											
b. Integration Cost	0.154	**0.857**										
c. Relative Advantage	0.282	0.437	**0.808**									
d. Compatibility	-0.061	-0.107	-0.121	**0.836**								
e. Complexity	0.227	0.432	0.559	-0.066	**0.764**							
f. Technology Readiness	0.036	0.000	0.087	-0.038	-0.032	**0.890**						
g. Technology Competence	0.113	0.561	0.736	-0.107	0.708	0.060	**0.823**					
h. Availability of Alternatives	0.218	0.530	0.723	-0.152	0.689	0.061	0.786	**0.925**				
i. Top Management Support	0.114	0.526	0.409	-0.110	0.535	0.077	0.485	0.480	**0.817**			
j. Organizational Readiness	0.137	0.527	0.722	-0.135	0.704	0.088	0.800	0.816	0.555	**0.915**		
k. Competitive Pressure	0.083	0.128	0.132	-0.060	0.064	-0.259	0.193	0.117	0.106	0.087	**0.823**	
l. CBS Development Adoption	0.192	0.483	0.734	-0.094	0.858	0.084	0.820	0.758	0.588	0.808	0.076	**0.990**

Note: The square root of AVE for each construct is the diagonal.

Table 4.7: Relevant constructs for the structure model.

Constructs	Path coeff.	T-Stat.	P-Value
Determinants of relative advantage of CBS development adoption in global context (direct effects)			
Development cost	0.220	2.529	0.012
Integration cost	0.403	4.333	0.000
		$R^2 = 0.225$	
CBS development adoption in global context determinants (direct effects)			
Relative advantage	0.206	3.468	0.001
Compatibility	0.007	0.159	0.874
Complexity	0.484	5.437	0.000
Technology readiness	0.047	1.453	0.147
Technology competence	0.210	2.408	0.016
Availability of alternatives	-0.038	0.661	0.509
Top management support	0.088	2.235	0.026
Organizational readiness	0.132	1.661	0.097
Competitive pressure	-0.027	0.667	0.505
CBS development adoption in global context determinants (indirect effects)			
Development cost	0.045	1.990	0.047
Integration cost	0.083	2.786	0.006
		$R^2 = 0.858$	

Note: Path Coefficient (Path coeff.), T-Statistic (T-Stat.).

the influence of other constructs of DOI theory, the effects of relative advantage (β=0.20; p <0.01), complexity (β=0.48; p <0.01) are statistically significant for the explanation of GD CBS development adoption, whereas the effect of compatibility (β=0.007; p >0.05) is not statistically significant. Thus, the hypotheses for relative advantage (H1), complexity (H3) are confirmed (p <0.01), whereas for compatibility (H2) is not confirmed (p >0.05) (RQ1 and RQ2).

To evaluate the influence of other constructs of TOE framework, the effects of technology competence (β=0.21; p <0.05), top management support (β=0.08; p <0.05) are statistically significant for the explanation of GD CBS development adoption, whereas the effect of technology readiness (β=0.04; p >0.05), availability of alternatives (β=-0.03; p >0.05), organizational readiness (β=0.13; p >0.05), competitive pressure (β=-0.02; p >0.05) are not statistically significant (RQ2). Thus, the hypotheses for technology competence (H7) (p <0.05), top management support (H9) (p <0.05) are confirmed, whereas for technology readiness (H6), availability of alternatives (H8), organizational readiness (H10), competitive pressure (H11) are not confirmed (p >0.05) (RQ1 and RQ2). In the research model, the indirect effect of development cost in GD CBS development adoption is the multiplication of the path coefficients of development cost (that explains relative advantage) and relative advantage (that explains GD CBS development adoption). So the multiplication of path coefficients (0.22*0.20) is 0.044. To assess the influence of development cost on GD CBS development adoption, the indirect effect of development cost (β=0.04; $p < 0.05$) on GD CBS development adoption is statistically significant (RQ2). Thus, the indirect effect of development cost on GD CBS development is confirmed ($p < 0.05$) (RQ1 and RQ2). Similarly, to assess the influence of integration cost on GD CBS development adoption, the indirect effect of integration cost (β=0.08; $p < 0.01$) on GD CBS development adoption is statistically significant (RQ2). Hence, the indirect effect of integration cost on GD CBS development is confirmed ($p < 0.01$) (RQ1 and RQ2). The integrative research model explains 85% of CBS development adoption in GD environment. The results of our analysis show significance of the integrative research model to explain the adoption of CBS development in global context.

4.3.3 Discussions

It is important to identify the determinants of globally distributed CBS development in GD environment, because globally distributed organizations want to accomplish successful software development projects and expect to mitigate the coordination and communication issues by adopting CBS development methodology in global context [18]. We performed an empirical investigation study for the assessment of the determinants of globally distributed CBS development adoption in GD environment by using an integration of DOI theory and TOE framework for innovation characteristics of CBS development and technological-organizational-environmental perspectives of globally distributed organizations. Four factors such as relative advantage, complexity, technology competence, and top management support were found statistically significant for influencing the adoption of globally distributed CBS development in GD context (*Table 4.7*) (RQ1).

Relative advantage (H1), a dependent construct of development cost and integration cost, has shown a positive influence on globally distributed CBS development in GD environment. Globally distributed organizations adopt CBS development to enhance the benefits that they are obtaining from the existing development practices [38]. The study also satisfy that globally distributed firms recognize the relative advantage of CBS development methodology (RQ1). To comprehend the influence of development cost and integration cost on globally distributed CBS development in GD environment, we evaluate the constructs. The results showed that development cost positively influence and integration cost negatively influence the adoption of globally distributed CBS development in GD organizations (RQ1). Globally distributed organizations prefer to adopt GD CBS development due to reduction in development cost, shorter time-to-market and use to COTS components [31]. Integration of components can go from easy to tough. Globally distributed organizations usually have employees with great skills and experience which is important for the integration of components [18].

Complexity (H3) has shown negative influence on globally distributed CBS development adoption in GD context (RQ1). Globally distributed organizations have challenges such as geographical, temporal and cultural differences that affected software development in terms of communication, coordination and control [9]. The adoption of globally distributed CBS development was expected to mitigate the problems of coordination and communication [38]. The results of our study showed that globally distributed organizations faced problems such as inter-dependency between components and distinctness in technical expertises etc. Technology competence (H5) has shown positive influence on GD CBS development in globally distributed environment (RQ1). Software reusability is gain with globally distributed CBS development practices. A modular component such as business component have much more potential to influence the success of a product in globally distributed CBS development [8]. The results of our study also indicate that top management support (H7) has shown a positive influence on globally distributed CBS development adoption in GD organizations (RQ1). Due to the absence of any empirically investigation study on the adoption of globally distributed CBS development in GD context, we were unable to show the similarity or difference between our findings and other studies.

Qualitative Analysis

In this research study, we identified and systematically evaluated the determinants that influence the adoption of CBS development in a global context. Moreover, in this section, we present a qualitative analysis of the determinants identified by the questionnaire survey, which helps in providing more insights to the researchers and practitioners. After assessing the identified determinants, some of them i.e.

development cost, integration cost, relative advantage, complexity, technology competence, and top management support are found statistically significant for influencing the adoption of CBS development in a global context. Whereas, rest of the determinants i.e. compatibility, technology readiness, availability of alternatives, organizational readiness, and competitive pressure are not perceived as important that impact the adoption of CBS development in a global context.

In this section, we have presented the qualitative analysis of the feedback shared by participants on the relationships between determinants during CBS development adoption. The experience of the participants is collected as part of an open ended question, namely, what and how different determinants influence the adoption of CBS development in a GSD project?. Therefore, the respondents agreed that 'development cost', 'integration cost', 'relative advantage', 'complexity', 'technology competence', and 'top management support' are key determinants that influence CBS development adoption in a global context. For example, one the respondents supported the significance of 'development cost' with the following comment:

"We introduced components, building as well as using COTS components, to our organization's development activities and kept in mind that it will potentially reduce development cost. Now, I am in a position to advise others to get cost benefits for their organization's development activities." Senior Project Manager

Similarly, integration cost is another key determinant that negatively influences the CBS development in a global context and the participants also agreed that the expertise required to integrate components is usually costly. Nevertheless, they also agreed that the integration process of the components in CBS development requires more efforts. For example, one of the participant express his viewpoint with the following comment:

"All sites of our organization usually follow pre-define strategies for integrating commercial-off-the-shelf (COTS) software components. Apart from this, we also have experts available at each site whom have experience in integrating and managing components, but still we are in a vulnerable position due to instant changes for software components in the software industry." System Analyst

Similar to development cost, the participant agreed that relative advantage is a key determinant and development activities with GD CBS development is easy to use and effective to maintain because of standardize components. This determinant is also supported by two of the participants with the following comments:

"I am existed to let you know that we have a pool of components in our organization that help us in performing our tasks more quickly." Senior Software Engineer

"Component-based development is easy due to the fact that it requires customization most of the time. The components meet the standards for most of development activities. I personally feel it easy when adding some components

that would have been provided by my colleague sitting in other site of organization to the on going project." Software Engineer

Furthermore, complexity is also accepted as an important determinant that negatively influences the adoption of CBS development in a global context. The participants agreed that it is difficult and requires more efforts to find suitable components when integrating components to form a large system. Similar to relative advantage, this determinant is also supported by two of the participants with the following comments:

"I am not sure if it is really important to others but I will not adopt CBS development, unless I have a reference architecture at hand for supporting my development activities for a successful project." Project Manager

"Our company has been very successful in developing small software projects with CBS development methodology for years but when it comes to integrating components for large software product, it somehow fails to deliver the end product at its schedule time. I believe it is a challenge for large software projects in CBS development." Team Leader

Technology competence is another key determinant from TOE framework that positively influences the adoption of GD CBS development. The participants agreed that they have employees who are technically strong and have sufficient skills in order to perform their development activities with GD CBS development. Therefore, one of the participant supported 'technology competence' with following comment:

"The expectations for adopting CBS development are high when employees of the organization has sufficient skills and knowledge in the use of CBS development methodology to deploy globally successful software development projects. Our organization has enough technological capabilities that allow us the global use of CBS development in all sites." Project Manager

Lastly, the participants agreed that top management support is a key determinant that positively influences the adoption of GD CBS development. The top-level management help and support the organization by allowing the use of CBS development in all sites of the organization. For example, one of the participants commented:

"We intend to seek the support from top-level management prior to adopt a development methodology for our development activities, therefore, it is an essential factor in the adoption process." Senior Software Engineer

Client vendor based analysis

In order to provide more insights to researchers and practitioners, we performed client vendor based analysis over collected data of all determinants and organizational background of the participants, which was requested in the demographic field of the questionnaire survey filtering if a participant is client or vendor in GSD. The collected data reflect the experience of participants from client and vendor perspective that were working in GSD-based project organizations. In order to find whether there is a significant relationship between the two categorical variables such as client and vendor from a single population, we applied the chi-square test of independence and its results are shown in *Table 4.8*. Therefore,

Null hypothesis: There is no significant association between the identified GD CBS development determinants from GSD client vendor perspective.

The findings in *Table 4.8*, a comparison of GD CBS development determinants from GSD client vendor perspective, shows that there are more similarities than differences among the respondents of our questionnaire survey. Moreover, the findings also shows that there are three significant differences (i.e., $p < 0.05$) among GSD organizations from client vendor perspective. The p-Value of development cost, integration cost, relative advantage, compatibility, technology readiness, availability of alternatives, top management support, and competitive pressure is not less than 0.05, therefore, we accept the null hypothesis and conclude that these GD CBS development determinants are independent of the client vendor perspective of GSD environment. Nevertheless, the p-Values of complexity, technology competence and organizational readiness determinants are 0.019, 0.038 and 0.049, respectively. Despite the fact that many GD CBS

Table 4.8: Chi square test results for client vendor data.

Constructs	Occurance in survey (n = 115)												
	Client (n = 42)					Vendor (n = 73)					Chi Square (linear by linear association) = 0.05		
	SA	A	N	D	SD	SA	A	N	D	SD	X2	Df	P-Value
Development cost	23	9	6	3	1	48	14	4	5	2	2.165	1	0.141
Integration cost	15	16	3	4	4	29	30	1	6	7	0.955	1	0.328
Relative advantage	19	10	7	5	1	24	24	9	11	5	3.000	1	0.083
Compatibility	16	12	5	6	3	26	23	9	7	8	0.468	1	0.497
Complexity	**16**	**16**	**6**	**2**	**2**	**31**	**25**	**6**	**5**	**6**	**5.453**	**1**	**0.019**
Technology readiness	17	11	5	6	3	22	24	11	8	8	1.662	1	0.197
Technology competence	**13**	**18**	**8**	**3**	**0**	**28**	**18**	**17**	**9**	**1**	**4.270**	**1**	**0.038**
Availability of alternatives	16	16	8	1	1	27	24	8	7	7	0.810	1	0.368
Top management support	25	6	6	5	0	42	14	8	9	0	0.631	1	0.426
Organizational readiness	**17**	**19**	**5**	**0**	**1**	**28**	**24**	**12**	**5**	**4**	**3.875**	**1**	**0.049**
Competitive pressure	19	8	4	10	1	27	20	8	15	3	1.217	1	0.271

development determinants do not show statistical difference, but the p-Values for complexity, technology competence and organizational readiness determinants are less than 0.05, therefore, our findings show significant differences for these three determinants and we reject our null hypothesis.

It is interesting to note that practitioners from client organizations (either strongly agreed or agreed, 76%) and vendor organizations (either strongly agreed or agreed, 77%) are equally likely aware of the 'complexity' that it is an important determinant for CBS development adoption in GSD projects. Similarly, practitioners from client organizations (either strongly agreed or agreed, 74%) and vendor organizations (either strongly agreed or agreed, 63%) shows that 'technology competence' is an important determinant for CBS development adoption in GSD projects and also that it is more important to client side rather than vendor side organizations. More interestingly, practitioners form client side organizations (either strongly agreed or agreed, 86%) and vendor side organizations (either strongly agreed or agreed, 71%) shows that 'organizational readiness' is an important determinant for CBS development adoption in GSD projects. The client vendor based analysis are summarized in *Table 4.8*.

Organization size based analysis

It is important to mention that organization size based analysis of the identified determinants give more deeper insight to the researchers and practitioners about the results at hand, therefore, we analyzed the significant determinants based on the sizes of target organizations. This allow us in gathering the respondents of our questionnaire survey into different groups such as 'small' and 'medium', defined by the size of the organizations as shown in *Table 4.9*. A small organization was consider small if it has less than 20 employees, whereas a medium organization was consider medium if it has 20 to 199 employees. Development cost and Top management support were appeared as significant determinants throughout small and medium GSD organizations. However, respondents from small GSD organizations show an agreement towards other determinants such as integration cost, relative advantage, complexity and competitive pressure in terms of significance. It is imperative to mention that the findings depict in *Table 4.9* does not provide any room for relative importance of these determinants by different viewpoint in this study, rather it depicts the significance of these determinants by different viewpoints.

Table 4.9: Summary results based on organization size based analysis.

Respondents' organization size	No. of significant determinants (cited as strongly agree by 50% of participants)
Small (n = 28)	6 determinants: Development cost Integration cost Relative advantage Complexity Top management support Competitive pressure
Medium (n = 87)	2 determinants: Development cost Top management support

Practical recommendations

This research work provides the state-of-the-art status of GD CBS development adoption research. In response to the feedback collected from the practitioners in an open end question, we provide some practical recommendations for the managers of GSD projects. The recommendations are:

- *GSD project managers should have a reference architecture for developing and using components in multiple software products across geographically distributed sites and it will potentially reduce development cost.*
- *To avoid complexity, GSD managers should assign component selection task to teams whom have knowledge and skills in understanding the need of appropriate components.*
- *GSD organizations need to create and have a repository of reusable components in order to achieve benefits of GD CBS development in a long run.*
- *GSD project managers should provide a mechanism for knowledge sharing among component developers of each site in the GD organizations.*
- *The importance of GD CBS development methodology and its relative advantages should be manifest to management in order to elicit support from top management.*

These practical recommendations regarding CBS development in global software development organizations allow GSD project managers to make informed decisions on implementing CBS development that will potentially improve the successful development and deployment of projects in GSD organizations.

CHAPTER 5

GD OSS DEVELOPMENT ADOPTION

Globally distributed OSS development has been adopted by globally distributed organizations because of its potential to produce improvements in software quality and cost reductions in globally distributed software development projects [24]. The main objective of this research study is to identify and investigate the determinants that influence the adoption of globally distributed OSS development methodology in the context of globally distributed organizations. The objectives in details are as: (1) to identify the determinants that influence the adoption of globally distributed OSS development in GD organizations; (2) to systematically evaluate the direct and indirect effects of determinants that influences globally distributed OSS development adoption in GD organizations. These objectives will help globally distributed software development organizations in better understanding the factors of GD OSS development adoption and its relative advantages.

To do this, we have addressed the following research questions:

- RQ3: What are the determinants that influence the adoption of globally distributed OSS development in GD organizations?
- RQ4: What are the direct and indirect effects of the determinants that influences globally distributed organizations to adopt GD OSS development methodology in global context?

In order to address the above research questions, we start by combining two important theoretical models such as DOI Theory [77] that shares prominent innovation characteristics and TOE framework [40] that has three prominent contexts such as technology, organization and environment. These two theoretical models are integrated to find out significant determinants for globally distributed OSS adoption in globally distributed organizations. The integration of DOI theory and TOE framework enriches the capability of the research model for explaining IT adoptions [103], reported in the Information Systems (IS) literature. Thus, in this research study, the influence of globally distributed OSS development diffusion in globally distributed organizations is shown through innovations characteristics of the DOI theory [77] and through technological, organizational, and environmental factors of the TOE framework [40].

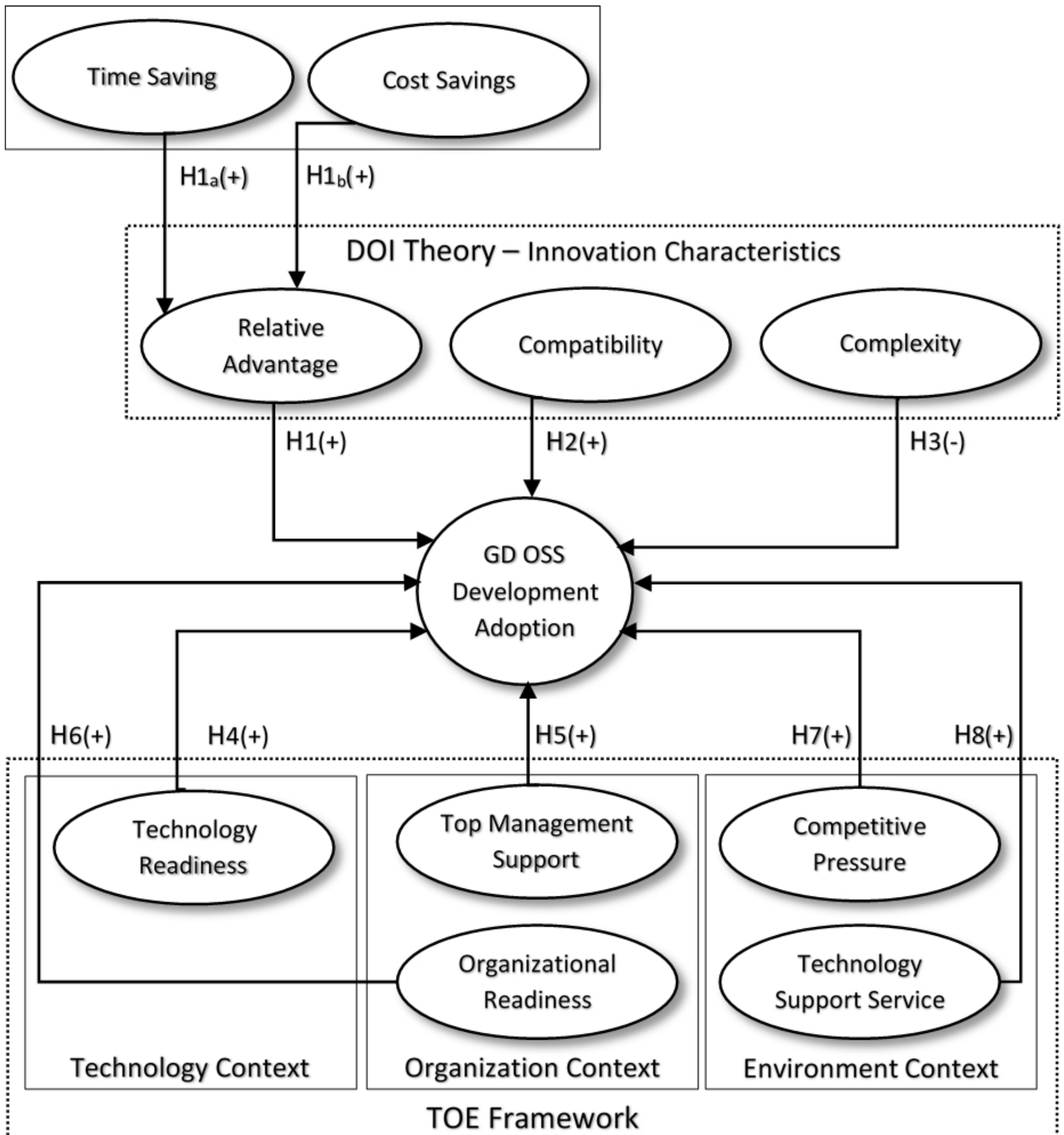

Figure 5.1: Research Model for Globally Distributed OSS Development Adoption

5.1 Research Model and Hypotheses

The determinants of our integrative conceptual research model as shown in *Fig. 5.1* is obtained from adoption theories and published literature on adoption of innovations and its studies. The important determinants for OSS diffusion from DOI theory are relative advantage, complexity, and compatibility [10, 13, 44, 46]. Furthermore, it is assumed that OSS generates time saving and cost savings advantages [24, 44, 25, 140]. Hence, we described the relative advantage of OSS as an individual construct as well as a composition of two constructs such as time saving and cost savings. These constructs help relative advantage to find out the benefits gained by the diffusion of OSS presuming that OSS provides time saving and cost savings. In addition, the three contexts of TOE framework for globally distributed OSS development adoption are: first, in the technological context of TOE framework, technology readiness [86] is significant for the diffusion of OSS [13, 25]; second, in the organizational context of TOE framework, top management support [86] and organizational readiness [84] are prominent for the diffusion of OSS [13, 44]; third, in the environmental context of TOE framework, competitive pressure [93] and technical support services [87] are significant for the diffusion of OSS [10, 25, 45].

5.1.1 DOI Theory Hypotheses

Relative advantage of an innovation is used to show the perceived and great organizational benefits than those existing innovations of the organization [77]. It refers to a degree of attractiveness to the target organization due to its organizational benefits and is known as a significant driver of IT innovations [141]. The motivation for an innovation's adoption is the accomplishment of effective strategies and its benefits (i.e., perceived benefits of OSS) [13, 124]. IT adoption and relative advantage has been contained a positive relationship [142], reported in literature. Commercial organizations have shown a great interest in the adoption of OSS [13]. In the case of GD OSS development, it provides better software quality, source code availability, productivity and helps in building developer's ownership attitude of the product in the target organizations [45, 12]. Hence,

H1. Relative advantage positively influences OSS development adoption in GD environment.

With the realization that IT organizations are working quick and smart, every other IT organization want to release their software product with less time-to-market. Time saving is an innovation's degree of quickness in understanding, thinking, and learning to the changes required for a software product in an organization. The OSS development reduces the time investment by enabling the available skills in the organization [44]. Moreover, the reuse of OSS components has also minimized the time for deployment of the software product [25]. OSS development enables organizations to produce quality software with short period of time by effectively using the best employees of the organization and meanwhile, maintain its standard with other competitors of the market [10]. Therefore,

H1a. Time saving positively influences OSS development adoption in GD environment.

The number of employees working on a software development product and the time taken for the completion of that software product with respect to overall project plan is known as cost from an estimation point-of-view [125]. If developers are building a similar portion of the software product on different sites in GD environment, then the organization is wasting its time as well as its employees. The usage of OSS development makes a reduction in the cost and allows the OSS communities to develop quality software with very small amount of cost by utilizing the profession of best programmers of the organization [10]. Another way of saving costs using OSS development is the use of free licenses for the OSS software products [13]. Moreover, cost savings in migration can also be achieved when deployment of OSS is performed [24]. Therefore, cost savings is relatively advantageous to the globally distributed organizations that consider OSS diffusion. Hence,

H1b. Cost savings positively influences OSS development adoption in GD environment.

Compatibility is one of the important constructs in the adoption studies where organizations are looking for the adoption of new innovations [82, 46, 127]; and it is an innovation's degree of adjustment and integration with the target organization's existing practices, processes and IT infrastructure [77]. One of the adoption approach for OSS development is to integrate the OSS products with other existing software products of the organization to increase software reuse and confirms compatibility [13]. OSS development provides standards (i.e. in terms of tools and methods) for its users (developers) in the working environment [44]. These OSS standards are compatible with the existing technologies [46] in all different geographical distributed sites of the organization. Therefore, this significant construct (i.e. compatibility) will determine the adoption of OSS development in GD environment. Thus,

H2. Compatibility positively influences OSS development adoption in GD environment.

Complexity shows the extend to which a technology is perceived to be relatively hard to use: the more it is difficult to integrate the innovation with existing practices of the target organization, the lesser the chances of its adoption by the target firm [77]. Not like previously, organizations are now focusing on easy-to-adopt approach for new innovations. An innovation is left off, if it is difficult to understand and operate [86]. The developers working in the communities of OSS paradigm are not commonly communicating face-to-face due to geographically distribution and need a large amount of time in a consistent manner for the target project [143]. Complexity discourages the application and use of new innovations, and reported as a construct that influence the adoption of a technology in a negative way [140] in the globally distributed organization. Therefore,

H3. Complexity negatively influences OSS development adoption in GD environment.

5.1.2 TOE Framework Hypotheses

The technology context

This is a significant context of the host organization that has technological attributes, abilities, characteristics, and standards for the adoption of new emerging innovations. Technology readiness is the extend to which a technology is perceived as being skillful to investments of the target organization [81]. Technology readiness of an organization is an important factor for adoption studies of innovation diffusion in globally distributed firms [83]. It includes structural aspects that refers to innovation's infrastructure, for example, services within the organization. These services can be replaced by OSS because it has introduced service-based models to the organizations [67]. Furthermore, OSS development does not require changes in the infrastructure of different sites of the organization due to its compliance with standards [13]. Technology readiness also include particular human resources i.e. IT professionals and IT infrastructure items [96]. Therefore, technology readiness is important for the adoption of OSS development in organizations. Hence,

H4. Technology readiness positively influences OSS development adoption in GD environment.

The organization context

The organizational context of an enterprise have different attributes and characteristics used for facilitation or restriction of technologies [129]. This context has significant elements and resources that leads to the adoption and implementation of a new innovation in the target organization [92]. The relationship between organizational context and the adoption of an innovation is affected by many determinants, for example, organizational readiness [84, 93], organizational structure [82, 86], top management support [86, 84], human and slack resources [46, 86], firm size [82, 86, 96, 83], power and control distribution, formal and informal communication [82, 46], and degree of centralization [82, 86]. The above all characteristics are descriptive, where top management support and organizational readiness are prominent for adopting OSS development in GD environment.

Top management support is a significant determinant for the success completion of a software project, and it supervises the allocation of resources, integration of services and re-engineering of components [86]. It is the responsibility of top management to focus on the advantages of OSS development tools for software product development through OSS communities [13]. Once the relative advantages are found: particular resources are allocated for the adoption of new innovation. After required resources allocation, members of the target organization are notified and convinced for this specific change in the existing practices. As a result, a new innovation is implemented along with its benefits. Other than that, the people of top management may not convince employees of the organization [86]. Moreover, top management support is known as a positive influencer for adopting technological innovation [144]. Thus,

H5. Top management support positively influences OSS development adoption in GD environment.

Organizational readiness is an important determinant of organization context and meanwhile also represents a combination of two contexts such as the technology and the organization context of TOE framework [93, 40]. Organizational readiness helps the target organization to show the change-commitment of employees and their shared confidence regarding the implementation of a change in the organization through adopting a new innovation [130]. Moreover, it also helps in looking for required organizational resources for the adoption of a technology [84]. The success of adopting OSS development depends on specification of the organization and organizational resources [13, 24]. OSS development, being an IT innovation, provides standards and allow the OSS community to contribute in terms of standardizing the practices and processes of the target organization. Hence,

H6. Organizational readiness positively influences OSS development adoption in GD environment.

The environmental context

The environmental context of TOE framework helps in understanding objectives of the organization, and refers to the domain for operations, internal processes, and strategies for conducting the business of organization [44, 97]. It is a kind of sittings that helps an organization to operate its business [86]. It also holds external support and services [45], and looks for activities related to market place such as market-nature, competitors, resources, and interactions with government [92]. Environmental context is also influenced by technical support services [82, 87], relevant technology support [82], regulatory support [82, 86] [87], competitive pressure [82, 86, 96, 83, 84, 93], perceived environmental barriers [86], market structure [82, 87], and entrepreneurial culture [86]. The above all characteristics are descriptive, where competitive pressure and technical support services are prominent for adopting OSS development in GD environment.

Competitive pressure is an essential driver for innovation diffusion, and it refers to the demand and pressure perceived by the adopting enterprise from competitors of the industry [93, 97]. In the literature of innovation diffusion, it has been recognized as an important determinant that explains the adoption of a an innovation [45]. Nowadays, an organization needs to adopt new innovations in terms of competing its competitors. Furthermore, competitive pressure (i.e. characteristic) can affect the response of a firm for the adoption of new technologies in order to compete in the industry [82]. OSS development, in terms of competitive pressure, is known for helping organizations to achieve great penetration of market-place and enlarge competitive advantage over its competitors [10], when it is intend to adopt OSS as a new innovation. Therefore,

H7. Competitive pressure positively influences OSS development adoption in GD environment.

Technical support services is a prominent determinant of innovation adoption, and is another environmental aspect of the industry [82]. Organizations prefer to adopt new innovation (i.e. OSS development), if its management team and workers understand the philosophy of OSS [10]. Otherwise, the organization need to skill its employees and provide relevant support services for the innovation being adopted [82]. One of the reputed benefits of OSS is the contribution of its community for the feature requests and bug reports [13]. Innovations with lack of technical support services in the target organization are more complicated and more-costly for adoption [82]. A user request can be quickly acknowledged by the use of OSS development [24]. Hence,

H8. Technical support services positively influences OSS development adoption in GD environment.

5.2 Research Methodology

In order to assess the determinants that influence the adoption of globally distributed OSS development, we first integrated two adoption theories such as

DOI Theory [39] and TOE Framework [40]. These theories have a number of determinants that researchers and practitioners use for identifying and systematically evaluating the adoption process of an innovation. In order to validate the theoretical determinants, we then searched for most-cited research studies on adoption of OSS development available in the published public domain and grouped them together to find out measurement items i.e. indicator variables or values for our determinants. We used the grounded theory-based coding scheme to review the literature and conceptualize the determinants for adopting OSS development in globally distributed environment. We then hypothesized that some of these determinants will positively relate and others will negatively relate to the adoption of OSS development in global context. We then used these determinants for developing an integrative conceptual research model as shown in *Fig. 5.1.* The research model is a combination of the innovation characteristics from DOI theory and three contexts of TOE framework such as technological, organizational, and environmental contexts.

In order to perform statistical analysis over the research model at hand and to perform analysis of hypotheses, we conducted a questionnaire survey that help us in collecting data from practitioners of globally distributed organizations. We then provide some qualitative analysis based on the data obtained from our questionnaire survey in order to give more insights to researchers and practitioners. The summary of our research design is shown in *Fig. 5.2.* The integrative research

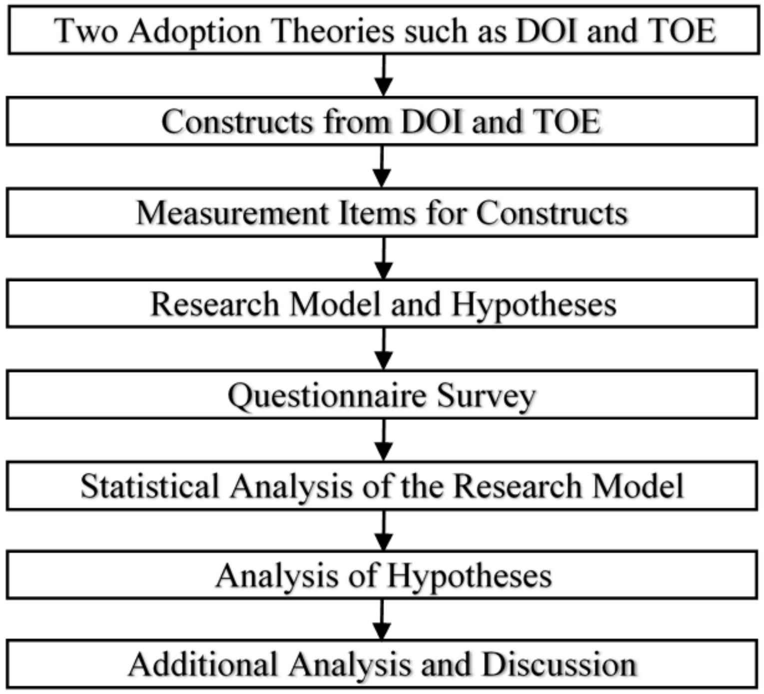

Figure 5.2: GD OSS Development Adoption Methodology

model helped us in integrating the two well-known adoption theories such as DOI theory and TOE framework and in showing the diffusion of globally distributed OSS development in a more holistic manner from globally distributed software development organizations' perspective. Furthermore, it is important to note that this process also helped us in selecting and identifying determinants that have been taken for evaluation process in the literature on adoption of innovations. Next, this also determined the relevance of identified determinants with OSS development adoption in global context. The details of our research methodology is discuss in the following sections.

Table 5.1: Sample characteristics (N = 198).

Company	Company area	Destination	Size	NP	Respondent's position
1	IT department	Australia	medium	18	IS manager, project manager, senior software engineer
2	IT department	Australia	medium	15	senior project manager, senior software engineer
3	Software consultancy	Australia	medium	13	senior software engineer, project manager
4	Software consultancy	Australia	medium	13	senior project manager, software engineer,IS manager
5	OSS development house	Australia	medium	11	team leader, project manager, IS manager
6	Software consultancy	Australia	medium	10	project manager, software engineer, IS manager
7	OSS development house	Australia	medium	9	team leader, project manager, IS manager
8	Software consultancy	Australia	medium	9	IS manager, project manager, senior software engineer
9	Software consultancy	Australia	medium	7	project manager, software engineer, IS manager
10	IT department	Australia	small	6	team leader, software engineer, programmer
11	OSS development house	Australia	small	5	software engineer, team leader
12	OSS development house	Australia	small	5	team leader, project manager
13	IT department	Asia	medium	17	IS manager, project manager, senior software engineer
14	Software consultancy	Asia	medium	14	system analyst, team leader, programmer
15	IT department	Asia	medium	13	team leader, project manager, IS manager
16	IT department	Asia	medium	9	team leader, project manager, programmer
17	IT department	Asia	small	6	system analyst, team leader, programmer
18	OSS development house	Asia	small	6	software engineer, team leader, system analyst
19	OSS development house	Asia	small	5	team leader, software engineer
20	OSS development house	Asia	small	4	system analyst, team leader, programmer
21	OSS development house	Asia	small	3	team leader, software engineer

Note: Number of Participant (NP).

5.2.1 Measurements

The theoretical determinants presented in our conceptual research model, which has an influence over the adoption of OSS development in GD environment, were taken for data collection. These measurement items (i.e. indicator variables) for each construct were obtained from the published literature of OSS development adoption. A questionnaire was created, to inspect the conceptual research model, by research professionals having experience in IS research. Therefore, this questionnaire was specifically related to the adoption of OSS development practices in GD environment, and these researchers have imparted their knowledge to it. For that reason, the questionnaire contributed in evaluating the influencing phenomenon of the factors that cause the adoption of OSS development in globally distributed organizations.

The researchers then conducted a survey using this questionnaire that has three sections such as: (1) practitioner's details, participants required to fill their background (where optional and mandatory options are included) for data collection; (2) demographics, participants required to fill this section with their experience and organization's background, regarding OSS development in GD environment, for data collection; (3) measurement items, five-point-likert scale was used for collecting data from the values (measurement items) of the construct that ranged from "strongly disagree" to "strongly agree". Furthermore, different number of measurement items (i.e. indicator variables), a minimum of 2 and a maximum of 3, were assigned to each construct (i.e. latent variable) of the measurement model as shown in *Table 5.2 and Table 5.3.* The last section of the questionnaire survey also asked for the experience of the respondents regarding the factors that influenced the adoption of OSS development in GD environment. Moreover, the reliability and validity of the scale used in questionnaire was checked by conducting a pilot study with 17 practitioners of 4 organizations. Furthermore, the results of this pilot study was not included in the details of our final sample. Therefore, once it is determined that the scale are valid and reliable, we then processed further data collection and its statistical analysis. *Table 5.1* shows the details of our sample (participants).

5.2.2 Data Collection

To acquire quality responses, the subjects i.e. individuals, that were having intimate knowledge of OSS development practices in the GD organizations, were considered as being the best or more suitable for the adopted innovation. Due to the fact that lower resources were available instead of approaching some commercial information providers such as Dun & Bradstreet, therefore, the questionnaire survey was conducted using snowball sampling technique [131]. Using this approach, the researchers then targeted contact points in the organizations. They were the people, whom would response to our survey with responsibility and make their contribution noteworthy. Furthermore, the reaction of a contact point is usually crucial in this case and does help in getting most

Table 5.2: Measurement Items for GD OSS Development (Part 1)

Constructs	Items	Adopted Source
Time saving	TS1 – OSSD facilitates you to produce quality software with short period of time.	[10, 24]
	TS2 – The use of OSSD allows firms to reduce 'time-to-market'.	
	TS3 – Organizations can reduce development time by using OSS development.	
Cost savings	CS1 – OSSD allows you to build quality software with little cost.	[13, 10, 24]
	CS2 – Cost reductions through savings in license fees can be achieved using OSS development	
Relative advantage	RA1 – OSS is easy to use and effective to maintain.	[44, 45, 10]
	RA2 – Using OSS allows the company to perform specific tasks more quickly.	
	RA3 – OSS development improves the quality of software products.	
Compatibility	CPT1 – OSS development standards are compatible with existing processes and operations.	[95, 13, 46]
	CPT2 – OSS is compatible with your current development process of the organization.	
	CPT3 – OSS as new technology is compatible with existing technologies, tasks and skills.	
Complexity	CX1 – The use of OSS development requires a mental effort.	[46, 24, 44]
	CX2 – The use of OSS development is frustrating.	
	CX3 – The skills needed to adopt OSS development are too complex for the employees of the organization.	
Technology readiness	TR1 – For adoption of OSSD, your company have enough human resources and IT infrastructure items.	[45, 13]
	TR2 – Your organization know how to support development activities by using OSS development.	
	TR3 – The skills needed for the implementation of OSS development is available in the firm.	

Note: All items are based on 5-point scale except those noted otherwise.

Table 5.3: Measurement Items for GD OSS Development (Part 2)

Constructs	Items	Adopted Source
Top management support	TMS1 – The implementation of OSSD is supported by the organization's management.	[24, 46]
	TMS2 – Your organizations management is ready to take risks i.e. financially and organizationally.	
Organizational Readiness	OR1 – Your company is confident about OSSD implementation for providing a change.	[95, 24]
	OR2 – For successful OSSD, your company depends on specification of organizational resources.	
Competitive pressure	CP1 – The use of OSSD allows to increase competitive advantage overs its competitors.	[10, 140]
	CP2 – For the adoption of OSSD your company is under pressure from competitors.	
Technical support services	TSS1 – The use of OSSD provides technical support through OSS communities.	[46, 140, 10]
	TSS2 – OSS communities allows free flow of information.	
OSSD adoption	OSSD1 – At what stage of OSSD adoption is your organization currently engaged? Not considering; Currently evaluating (e.g., in a pilot study); Have evaluated, but do not plan to adopt this technology; Have evaluated and plan to adopt this technology; Have already adopted processes, practices or infrastructure of Open Source Software Development.	[98]
	OSSD2 – If you are forecasting that your company will adopt OSSD in the future. How do you think it will happen? Not considering; More than 5 years; Between 2 and 5 years; Between 1 and 2 years; Less that 1year; Have already adopted processes, practices or infrastructure of Open Source Software Development.	

Note: All items are based on 5-point scale except those noted otherwise.

of the responses. In our case, individuals like project managers were suitable as contact points because they used to know about each other (different) sites of the organization (in a globally distributed context), even staying at only one site in a different country. Moreover, project managers can also have access to information available in different sites of a GD organization. Other than this, they also keep an eye on changes regarding the adoption of new innovations in different sites of the organization. These contact points were approached by providing a web-based questionnaire via email and were asked to readdress it to key informants of their organizations.

In addition to this, the researchers were able to collect significant data and make a comparison between knowledgeable versus unknowledgeable respondents through "key informants" approach [132]. Furthermore, the total of completed questionnaire surveys were recorded with respect to its organization because the contact points were interrogated by researchers to report a total frequency of the respondents corresponding to their firms. Organizations, small to medium in size, from different countries such as Australia and some from Asia were targeted for collecting data. These were such organizations that provide OSS development services in globally distributed context. An organization size can be obtain by knowing the number of its employees. Therefore, data regarding the organization's size was collected in demographics section of the questionnaire survey. In this research, a small organization was consider small if it has less than

20 employees, whereas a medium organization was consider medium if it has 20 to 199 employees. The researchers particularly mentioned about the exigency of technical expertises of the respondents in order to increase the content validity of questionnaire survey. Therefore, participants were required to have a technical degree such as computer science or any relevant that helps in understanding OSS development.

Furthermore, organizations were checked for having at least one full time IS professional via communicating contact points. Moreover, the survey ranged the participants from project managers to IS managers and were asked for the knowledge regarding the adoption of OSS development in GD environment. Nevertheless, data collection for this research study was performed in one phase. To increase response rate, the researchers provided the findings of this study to the respondents and informed them about the confidentiality of their names and organization's name. An increase in the response rate was also gained due to snowball sampling technique [131]. In only one session, *from 15th-February to 10th-April of the year 2017*, the questionnaire survey was conducted. During this session, the researchers approached 620 participants. Correspondingly, the number of received responses were 206, which then manually examined by the researchers for any incomplete data that caused the exclusion and rejection of 8 responses. Moreover, the remaining 198 valid responses were taken for further analysis. The minimum response rate of an organization is 3, whereas, the maximum response rate of an organization is 18.

Interested participants were informed about the accessibility of the findings of this research in order to increase the participation rate. Participants were notified regarding the confidentiality of their data in order to complete the questionnaire. Only one session was used for conducting questionnaire survey. Furthermore, the response rate of our survey such as 32%, is comparable with other studies [96]. Moreover, small companies were 38% (8 firms) and medium companies were 62% (13 firms) out of a very small number of companies, whereas, responses from Australia were noted 61% and from Asia were noted 39%. Nevertheless, *Table 5.4* presents mean and standard deviation of all the determinants used in the conceptual research model.

Table 5.4: Mean, Standard Deviation, and Reliability Indicators.

Constructs	Mean	SD	AVE	CR
Time saving	3.93	0.73	0.563	0.795
Cost savings	3.89	0.74	0.747	0.855
Relative advantage	3.78	0.52	0.767	0.908
Compatibility	3.50	0.74	0.698	0.874
Complexity	4.03	0.72	0.625	0.833
Technology readiness	3.73	0.59	0.685	0.866
Top management support	3.82	0.41	0.943	0.971
Organizational readiness	3.67	0.57	0.813	0.897
Competitive pressure	3.89	0.59	0.870	0.931
Technical Support Service	3.84	0.61	0.750	0.857
OSS development adoption	3.60	0.45	0.960	0.980

Note: Standard deviation (SD), average variance extracted (AVE), and composite reliability (CR).

5.3 Results and Discussion

The integrative conceptual research model as shown in *Fig. 5.1* was empirically assessed using Structural equation modeling (SEM). In SEM, we choose variance-based technique such as Partial Least Squares (PLS) path modeling for the analysis. It is required when model is complex and described theoretical information is low [136]. The minimum sample size requirement for using PLS estimation is as follows: (1) it should be 10 times the largest number of indicator variables used to measure one latent variable; or (2) in a structural model, it should be 10 times the largest number of structural paths directed at a latent variable [137, 86]. We have satisfied the basic conditions as our sample for globally distributed OSS development adoption consists of 198 participants. Before going to test different structural models for GD OSS development adoption in global context, we evaluate the validity and reliability of the measurement model by using smartPLS [47, 137].

5.3.1 Measurement Model

The measurement model was taken to confirm reliability and validity. *Table 5.4* shows their results for the model. To test reliability, the researchers examined the scales through composite reliability (CR). If all constructs provide CR values greater than 0.7, then reliability of the scales is confirmed. So true in our case, we received all constructs with CR values greater than 0.7, therefore, confirms reliability of the scales [136]. To ensure validity, we then examined convergent validity through average variance extracted (AVE). Similar to reliability, if all factors provide AVE values greater than 0.5, then convergent validity of the scales is confirmed. In our case, we received all factors with AVE values greater than 0.5, thus, confirms convergent validity [138]. This shows that the determinants explains more than 50% of the variance of its indicator variables (i.e. measurement items) [138]. To test indicator reliability, the researchers examined loadings of the measurement model. Similar to reliability and validity, if all indicator variables provide loading values greater than 0.7, then indicator reliability of the items is confirmed. This is true for our case, we received all measurement items with loading values greater than 0.7, therefore, confirms indicator reliability at significance level 0.01 (except two that are at significance level 0.05) as shown in *Table 5.5*. Because the indicator reliability is satisfied, the researchers continue to have these measurement items as shown in *Table 5.2 and Table 5.3*.

Nevertheless, to assess the discriminant validity of the determinants, two measures were used such as Fornell-Larcker criteria and cross-loadings. If all the correlations between factors are less than the square root of AVE of the respective factors, then Fornell-Larcker criterion is confirmed [138]. In our case, we obtained all correlations (between pair of factors) less than the square root of AVE, therefore, confirms Fornell-Larcker criteria as shown in *Table 5.6*. Similarly, if all the cross-loadings are less than the loadings of each measurement item, then

Table 5.5: PLS loadings for GD OSS Development.

Items	Loading	T-statistics	P-value
TS1	0.766	10.885	0.000
TS2	0.714	7.848	0.000
TS3	0.771	11.166	0.000
CS1	0.920	50.198	0.000
CS2	0.804	14.630	0.000
RA1	0.852	31.433	0.000
RA2	0.892	50.548	0.000
RA3	0.883	36.185	0.000
CPT1	0.857	2.940	0.003
CPT2	0.817	2.477	0.014
CPT3	0.831	2.570	0.010
CX1	0.849	27.966	0.000
CX2	0.765	19.653	0.000
CX3	0.755	14.333	0.000
TR1	0.722	9.193	0.000
TR2	0.896	34.438	0.000
TR3	0.855	18.968	0.000
TMS1	0.970	90.466	0.000
TMS2	0.972	102.547	0.000
OR1	0.872	6.279	0.000
OR2	0.931	9.003	0.000
CP1	0.925	45.083	0.000
CP2	0.941	74.842	0.000
TSS1	0.816	14.637	0.000
TSS2	0.913	31.708	0.000
OSSD1	0.980	383.186	0.000
OSSD2	0.979	334.636	0.000

Note: All items are based on five-point scale except those noted otherwise.

Table 5.6: Correlations of the Constructs and AVEs.

Constructs	a	b	c	d	e	f	g	h	i	j	k
a. Time Saving	**0.751**										
b. Cost Savings	0.357	**0.864**									
c. Relative Advantage	0.384	0.514	**0.876**								
d. Compatibility	-0.089	-0.119	-0.178	**0.835**							
e. Complexity	0.370	0.365	0.733	-0.065	**0.791**						
f. Technology Readiness	0.135	0.350	0.494	-0.095	0.351	**0.828**					
g. Top Management Support	0.110	0.360	0.555	-0.089	0.517	0.522	**0.971**				
h. Organizational Readiness	-0.015	0.089	0.159	-0.315	0.169	0.084	0.050	**0.902**			
i. Competitive Pressure	0.381	0.467	0.783	-0.100	0.764	0.340	0.577	0.179	**0.933**		
j. Technical Support Service	0.717	0.341	0.417	0.012	0.350	0.146	0.199	-0.133	0.366	**0.866**	
k. OSS Development Adoption	0.337	0.437	0.823	-0.072	0.850	0.359	0.591	0.137	0.849	0.384	**0.980**

Note: The square root of AVE for each construct is the diagonal.

cross-loadings criterion is confirmed [139]. So true in our case, we examined the loadings and cross-loadings tables that clearly show that loadings are greater than cross-loadings, therefore, confirms cross-loading criteria (these specific tables can be available on request from the authors of this Thesis). Thus, discriminant validity is confirmed by these two measures. At last, the aim of these assessments on measurement model is to confirm the use of constructs described in the conceptual research model for further evaluations and investigation.

5.3.2 Structural Model

The structural model was taken to confirm multicollinearity and hypotheses. Variance inflation factors (VIF), where the traditional threshold value is 5, is used to confirm any concerns of multicollinearity. If all constructs provide VIF values less than 3, then no multicollinearity is confirmed. So true in our case, we received all constructs with VIF values less than 3 (and less than 5 for few constructs), therefore, there exists no multicollinearity among the constructs of our integrative conceptual research model. Nevertheless, the standardized paths of the research model were investigated for the analysis of either accepting or rejecting of the hypotheses of our identified determinants for GD OSS development adoption (RQ3). If a hypothesis is accepted, then the corresponding construct influence the adoption of OSS development in GD environment is confirmed, otherwise it doesn't confirm and the hypothesis is rejected.

Table 5.7: Relevant constructs for the structure model.

Constructs	Path coeff.	T-Stat.	P-Value
Determinants of relative advantage of OSS development adoption in GD context (direct effects)			
Time saving	0.230	3.442	0.001
Cost savings	0.432	5.614	0.000
	$R^2 = 0.303$		
OSS development adoption in GD context determinants (direct effects)			
Relative advantage	0.298	4.847	0.000
Compatibility	0.033	0.754	0.451
Complexity	0.385	6.349	0.000
Technology readiness	-0.070	2.215	0.027
Top management support	0.096	2.068	0.039
Organizational readiness	-0.016	0.477	0.634
Competitive pressure	0.293	4.057	0.000
Technical Support Services	0.006	0.187	0.851
OSS development adoption in GD context determinants (indirect effects)			
Time saving	0.068	2.653	0.008
Cost savings	0.129	3.795	0.000
	$R^2 = 0.845$		

Note: Path Coefficient (Path coeff.), T-Statistic (T-Stat.).

The statistical significance of PLS-SEM results such as path coefficients were investigated by means of a nonparametric method i.e. bootstrapping (with 500 re-samples). *Table 5.7* shows a summary of the resulted path coefficients along with other analysis such as T-statistics and P-value (RQ4). Moreover, the examination of R^2, a statistic that gives some information about the goodness-of-fit of a model or defines perfect predictive accuracy, shows that time saving and cost savings explains 30% of the relative advantage of GD OSS development adoption. The direct effects of the determinants on relative advantage are evaluated. The resulted outcome for time saving with path coefficient (β=0.23; T-value =3.44) and calculated probability ($p < 0.01$) has an effect on relative advantage that shows statistical significance (RQ4). Hence, the hypothesis of time saving as an independent latent variable for relative advantage of GD OSS development (H1a) is confirmed and accepted ($p < 0.01$) (RQ3 and RQ4). Similarly, the resulted outcome for cost savings with path coefficient (β=0.43; T-value =5.61) and calculated probability ($p < 0.01$) has an effect on relative advantage that also shows statistical significance (RQ4). Thus, the hypothesis of cost savings as an independent latent variable for relative advantage of GD OSS development (H1b) is confirmed and accepted ($p < 0.01$) (RQ3 and RQ4).

The direct effects of other determinants of DOI theory are also evaluated. The resulted outcomes for relative advantage with path coefficient (β=0.29; T-value =4.84) and calculated probability ($p < 0.01$), complexity with path coefficient (β=0.38; T-value =6.34) and calculated probability (p <0.01) has an effect on GD OSS development adoption that show statistical significance, whereas, the outcomes for compatibility with path coefficient (β=0.03; T-value =0.75) and calculated probability (p >0.05) has no statistically significant effect on GD OSS development adoption (RQ4). Therefore, the hypothesis for relative advantage (H1), complexity (H3) are confirmed and accepted (p <0.01), whereas for compatibility (H2) is not confirmed and rejected (p >0.05) (RQ3 and RQ4).

The direct effects of the determinants of TOE framework are also assessed as follows: the resulted outcomes for technology readiness with path coefficient (β=-0.07; T-value =2.21) and calculated probability (p <0.05); and top management support with path coefficient (β=0.09; T-value =2.06) and calculated probability (p <0.05); and competitive pressure with path coefficient (β=0.29; T-value =4.05) and calculated probability (p <0.01) has an effect on GD OSS development adoption that show statistical significance (RQ4). Whereas, the outcomes for organizational readiness with path coefficient (β=-0.01; T-value =0.47) and calculated probability (p >0.05); and technical support services with path coefficient (β=0.006; T-value =0.18) and calculated probability (p >0.05) has no statistically significant effect on GD OSS development adoption (RQ4). Therefore, the hypotheses for technology readiness (H4) (p <0.05), top management support (H5) (p <0.05), competitive pressure (H7) (p <0.01) are confirmed and accepted, whereas for organizational readiness (H6), technical support services (H8) are not confirmed and rejected ($p > 0.05$) (RQ3 and RQ4).

With regard to indirect effects of independent latent variables such as time saving and cost savings on the adoption of OSS development in GD environment, the resulted path coefficients of relative advantage (that explains GD OSS development adoption) and these independent variables (that explains relative advantage) are multiplied with each other. Thus, the multiplication of time saving with relative advantage (0.23*0.29) results in a new path coefficient i.e. 0.06 for time saving, whereas, the multiplication of cost savings with relative advantage (0.43*0.29) results in another new path coefficient i.e. 0.12 for cost savings. To evaluate the influence of time saving on GD OSS development adoption, the new resulted outcome for time saving with path coefficient (β=0.06; T-value =2.65) and calculated probability ($p < 0.01$) has an effect on GD OSS development adoption that shows statistical significance (RQ4). Hence, the indirect effect of time saving on GD OSS development is confirmed and accepted ($p < 0.01$) (RQ3 and RQ4). Similarly, to evaluate the influence of cost savings on GD OSS development adoption, the new resulted outcome for cost savings with path coefficient (β=0.12; T-value =3.79) and calculated probability ($p < 0.01$) has an effect on GD OSS development adoption that shows statistical significance (RQ4). Therefore, the indirect effect of cost savings on GD OSS development is confirmed ($p < 0.01$) (RQ3 and RQ4). Nevertheless, our integrative conceptual research model explains 84% of GD OSS development adoption and the analysis for hypotheses show the statistical significance of the our conceptual research model to explain the adoption of OSS development in GD context.

5.3.3 Discussions

In order to produce improvements in software quality and cost reductions in globally distributed software development projects, globally distributed organizations need to identify and systematically evaluate the determinants that influence the adoption of globally distributed OSS development methodology in global context (RQ3). To help globally distributed organizations in this regard, we have empirically investigated the determinants that influence the adoption of globally distributed OSS development in a global context with the help of an integrative conceptual research model. The research model combines the DOI theory for innovation characteristics of globally distributed OSS development and TOE framework for technology, organization, and environment contexts of globally distributed organizations for the adoption of GD OSS development methodology. The results of this research study found that five determinants such as relative advantage, complexity, technology readiness, top management support, and competitive pressure are statistically significant for influencing the adoption of globally distributed OSS development methodology in global context *(see Table 5.7)* (RQ3). The findings of our study except for competitive pressure has no contradictions with similar studies published in the literature [45, 44, 46, 140, 10].

From the innovation characteristics of DOI theory, relative advantage (H1) has shown positive influence on the adoption of globally distributed OSS development in globally distributed organizations (RQ3). Other similar studies reported relative advantage (perceived benefits) as an influencer for the adoption of OSS development in global context [45, 46]. Relative advantage and IT adoption has been contained a positive relationship [142] reported in literature and it is a dependent determinant of time saving and cost savings presented in our research model. Globally distributed organizations adopt OSS development methodology to gain better software quality, free source code availability, and helps in building developer's ownership attitude of the software product [45, 12]. Nevertheless, the findings of this study also satisfy that globally distributed organizations recognize the relative advantages of globally distributed OSS development methodology such as easy to use, effective to maintain, perform specific tasks more quickly and improves the quality of software products.

Similarly, we evaluated the independent determinants of relative advantage that are time saving and cost savings to comprehend the influence of the adoption of globally distributed OSS development in global context. The results of our study have shown that time saving and cost savings have positively influence the globally distributed OSS development adoption in globally distributed organizations (RQ3). In the literature, other similar studies reported time saving and cost savings as an influencer for the adoption of OSS development in global context [44, 10, 46]. Globally distributed organizations prefer to adopt globally distributed OSS development methodology due to reducing the time investment by enabling the available skills in the organization [44] and reusing of OSS components that minimize deployment time of the software product [25]. Moreover, the findings of our study also satisfy that globally distributed OSS development methodology allows organizations not only to reduce 'time-to-market' and development time but also produce quality software with short period of time [10, 24]. Similarly, globally distributed organizations are interested in the adoption of globally distributed OSS development methodology due to reduction in cost by utilizing the profession of best programmers of the organization [10] and free licenses for the OSS software products [13]. The results of our study also satisfy that globally distributed organizations produce quality software with little cost and achieve cost reductions through savings in license fees with the help of globally distributed OSS development methodology [13, 10, 24].

From the other innovation characteristics of DOI theory, complexity (H3) has shown negative influence of globally distributed OSS development adoption in globally distributed organizations (RQ3). Other similar studies also reported complexity as a negative influencer for the adoption of OSS development in global context [140, 44]. Globally distributed organizations have challenges such as geographical, temporal, and cultural differences that affected software development methodologies in terms of face-to-face communication and coordination. The influence of complexity is negative over the adoption of OSS development [140] and discourages the globally distributed organizations to adopt a new innovation. The results of our study show that, in regard to accept GD OSS development methodology, the globally distributed organizations faced problems such as the skills needed to adopt OSS development methodology are too complex for the employees of the adopting organization and OSS development methodology requires more mental effort (RQ3).

From the technology context of TOE framework, technology readiness (H4) has shown positive influence on the adoption of globally distributed OSS development in globally distributed organizations (RQ3). Other similar study also reported technology readiness as an influencer for the adoption of OSS development in global context [?]. In fact, technology readiness is an important determinant for adoption studies of innovation diffusion in globally distributed organizations [83]. Globally distributed organizations do not need to change their infrastructure of different sites when intend to adopt OSS development methodology [13]. The findings of our study also confirms that globally distributed organizations know how to support development activities and know to have enough human resources and IT infrastructure items when adopting globally distributed OSS development methodology. Similarly, from the organization context of TOE framework, top management support (H5) has shown a positive influence on the adoption of globally distributed OSS development in globally distributed organizations (RQ3).

Whereas, from the environment context of TOE framework, competitive pressure (H7) has shown positive influence on the adoption of globally distributed OSS development in globally distributed organizations (RQ3). Moreover, no study has reported technology readiness as an influencer for the adoption of OSS development in global context. Apart from that, competitive pressure is an important driver for innovation diffusion [93]. The results of our study confirm that globally distributed organizations are under pressure in terms of competition that motivate them to adopt globally distributed OSS development methodology.

Qualitative Analysis

This research study presents the process of identification and systematically evaluation of the determinants that influence the adoption of GD OSS development. Therefore, in this section, we have presented a qualitative analysis of the determinants identified by the questionnaire survey with believing that this analysis will help in providing more insights to the researchers and practitioners. The assessment process over the identified determinants resulted in finding some statistically significant determinants for influencing the adoption of GD OSS development. These determinants are: time saving, cost savings, relative advantage, complexity, technology readiness, top management support, and competitive pressure. Whereas, the other determinants such as compatibility, organizational readiness, and technical support service are not perceived as important that impact the adoption of GD OSS development.

Therefore, we have presented the qualitative analysis of the feedback shared by participants on the relationships between determinants during GD OSS development adoption. The experience of the participants is collected as part of an open ended question, namely, 'what and how different determinants influence the adoption of OSS development in a GSD project?'. Therefore, the participants agreed that 'time saving', 'cost savings', 'relative advantage', 'complexity', 'technology readiness', 'top management support', and 'competitive pressure' are key determinants that influence GD OSS development adoption. For example, two of the participants supported the significance of 'time saving' with the following comments:

"We follow a checklist for reviewing our code by senior software developers through collaborative code review tools." Programmer

"I wonder if an organization is not in the queue for executing its development deadlines before the actual deadlines. I strongly recommend the use of OSS development in all sites of the organization in order to get the software product early into the market place." System Analyst

Moreover, the participants agreed that cost savings is also a key determinant that positively influence the GD OSS development adoption and GSD organizations adopt OSS development methodology for cost effective quality software. Nevertheless, they also agreed that GSD organizations can reduce cost through savings in license fees when practicing OSS development. Cost savings is supported by one of the participant with the following comment:

"Free source code and open source licenses are the advantages of open source development, but they sometimes become restrictive in order to make modification. In general, I have a positive believe that OSS reduces the cost and time in your development activities." Senior Software Engineer

Similar to cost savings, the respondents agreed that relative advantage is a key determinant and development activities with GD OSS development is easy to use and effective to maintain because of the continuous support from OSS community and the use of standardize OSS components. This determinant is also supported by one of the participants with the following comment:

"We started OSS development long-ago and now we have established standard components for all sites of our organization by simply modifying the existing open source code." Senior Software Engineer

Complexity is another important determinant that negatively influences the adoption of GD OSS development. The participants agreed that the use of OSS development requires a mental effort and it is frustrating. Similar to other determinants, it is also supported by a participant with the following comment:

"I have experienced that organizations do not consider the local site expertise when going for OSS components and therefore, they fail to achieve the benefits related to the adoption of OSS development methodology." Senior Project Manager

Furthermore, technology readiness is another key determinant from TOE framework that positively influences the adoption of GD OSS development. The participants agreed that GSD organizations know how to support development activities by using OSS development. Moreover, they also agreed that GSD organizations have skillful employees who can use of the implementation of OSS development. Therefore, one of the participant supported 'technology readiness' with following comment:

"I strongly recommend to have a robust infrastructure for communication and coordination between GSD teams across different sites while practicing software development with OSS development methodology. Otherwise, it will be difficult to gain success in GSD projects." Project Manager

Top management support is another key determinant that positively influences the adoption of GD OSS development. The top-level management help and support the organization by allowing the use of OSS development in all sites of the organization. For example, one of the participant give his feedback as follows:

"There is no second opinion about implementation and adoption of an innovation without the agreement of top management. We set together in order to see what resources, services, and infrastructure etc will be required if we are going to adopt an innovation. Therefore, it is crucial and effective for an organization to follow up with their top management". Senior Project Manager

Lastly, the participants agreed that competitive pressure is an important determinant that positively influences the adoption of GD OSS development. Moreover, they agreed that GSD organizations are under pressure from their competitors in the software industry. For example, one of the participants commented:

"We keep an updated strategic policy regarding competition in the market. In order to survive and fit in today's market place, we adopt and maintain all the changes impose by OSS development." Senior Software Engineer

Client vendor based analysis

This study provide more insights to researchers and practitioners by analyzing collected data of all determinants and organizational background of the respondents from client vendor based analysis perspective. The organizational background was recorded from a demographic field listed in our questionnaire survey that helps in finding if a respondent is client or vendor in GSD. The collected responses reflect the experience of participants from client and vendor perspective that were working in GSD-based project organizations. We applied chi-square test of independence in order to find whether there is a significant relationship between the two categorical variables such as client and vendor from a single population. The results of chi-square test are shown in *Table 5.8.* Therefore, our hypothesis is as follows:

Null hypothesis: There is no significant association between the identified

GD OSS development determinants from GSD client vendor perspective.

It is interesting to point out that there are more similarities than differences among the participants by comparing GD OSS development determinants from GSD client vendor perspective, as shown in *Table 5.8.* Moreover, the results show that there are four significant differences (i.e., $p < 0.05$) among GSD organizations from client vendor perspective. The p-Value of time saving, relative advantage, compatibility, technology readiness, top management support, and technical support service is not less than 0.05, therefore, we accept the null hypothesis and conclude that these GD OSS development determinants are independent of the client vendor perspective of GSD environment. Nevertheless, the p-Values of cost savings, complexity, organizational readiness, and competitive pressure determinants are 0.001, 0.020, 0.041 and 0.010, respectively. Despite the fact that many GD OSS development determinants do not show statistical difference, but the p-Values for cost savings, complexity, organizational readiness, and competitive pressure determinants are less than 0.05, therefore, our findings show significant differences for these four determinants and we reject our null hypothesis.

Industrial practitioners from client organizations (either strongly agreed or agreed, 77%) and vendor organizations (either strongly agreed or agreed, 78%) are equally likely aware of the 'cost savings' that it is an important determinant for

Table 5.8: Chi square test results for client vendor data.

Constructs	Occurance in survey (n = 198)												
	Client (n = 66)					Vendor (n = 132)					Chi Square (linear by linear association) = 0.05		
	SA	A	N	D	SD	SA	A	N	D	SD	X2	Df	P-Value
Time saving	29	17	7	7	6	68	35	8	11	10	2.100	1	0.147
Cost savings	**28**	**23**	**9**	**3**	**3**	**82**	**21**	**18**	**6**	**5**	**10.215**	**1**	**0.001**
Relative advantage	26	17	6	9	8	71	24	14	17	6	2.361	1	0.124
Compatibility	31	7	10	10	8	63	20	15	20	14	1.262	1	0.261
Complexity	**35**	**14**	**10**	**2**	**5**	**73**	**31**	**11**	**7**	**10**	**5.385**	**1**	**0.020**
Technology readiness	32	15	5	7	7	60	27	18	20	7	2.399	1	0.121
Top management support	32	12	12	12	5	68	26	15	12	11	1.781	1	0.182
Organizational readiness	**33**	**15**	**2**	**9**	**7**	**63**	**33**	**13**	**16**	**7**	**4.140**	**1**	**0.041**
Competitive pressure	**33**	**14**	**9**	**3**	**7**	**72**	**32**	**14**	**9**	**5**	**6.548**	**1**	**0.010**
Technical Support Service	28	19	5	9	5	73	26	17	10	6	2.443	1	0.118

OSS development adoption in GSD projects. Similarly, practitioners from client organizations (either strongly agreed or agreed, 74%) and vendor organizations (either strongly agreed or agreed, 79%) shows that 'complexity' is an important determinant for OSS development adoption in GSD projects and also that it is more important to vendor side rather than client side organizations. It is interesting to note that practitioners from client organizations (either strongly agreed or agreed, 73%) and vendor organizations (either strongly agreed or agreed, 73%) are equally likely aware of the 'organizational readiness' that it is an important determinant for OSS development adoption in GSD projects. Nevertheless, practitioners form client side organizations (either strongly agreed or agreed, 71%) and vendor side organizations (either strongly agreed or agreed, 79%) shows that 'competitive pressure' is an important determinant for OSS development adoption in GSD projects and also that it is more important to vendor side rather than client side organizations. The *Table 5.8* shows the summary of client vendor based analysis.

Organization size based analysis

A deeper insight to the industrial practitioners about the findings can be provided by conducting organization size based analysis of the identified determinants that influence the adoption of OSS development in global context. Hence, we analyzed the significant determinants based on organization size. An organization size can be obtain by knowing the number of its employees. Therefore, data regarding the organization's size was collected in a demographics field of the questionnaire survey. This help us in grouping the respondents in to two different groups such as 'small' and 'medium' based on their organization size. Employees less than 20 means small-sized-organization and between 20 to 199 means medium-sized-organization.

Cost savings and competitive pressure were appeared as significant determinants throughout small and medium GSD organizations. However, respondents from small GSD organizations agreed that technical support service is more significant for them rather than medium GSD organizations. Whereas, respondents from medium GSD organizations show an agreement towards other determinants such as time saving, complexity, and top management support in terms of significance. It is imperative to note that the findings presented in *Table 5.9* does not provide any information regarding relative importance of these determinants by different viewpoints, rather it provides the information regarding the significance

Table 5.9: Summary results based on organization size based analysis.

Respondents' organization size	No. of significant determinants (cited as strongly agree by 50% of participants)
Small (n = 40)	3 determinants: Cost savings Competitive pressure Technical support services
Medium (n = 158)	5 determinants: Time saving Cost savings Complexity Top management support Competitive pressure

of these determinants by different viewpoints.

Practical recommendations

This research work provides the state-of-the-art status of GD OSS development adoption research. In response to the feedback collected from the practitioners in an open end question, we provide some practical recommendations for the managers of GSD projects. The recommendations are:

- *GSD practitioners should increase OSS development practices for appropriate use of OSS development methodology through peer code reviews in order to build quality software in GSD organizations.*
- *For a long run in the market, GSD project managers should consider contributing in to OSS communities for a return back in form of technical support service.*
- *The importance of GD OSS development methodology and its relative advantages should be manifest to management in order to elicit support from top management.*
- *It is important for GSD project managers to look for local site expertise when selecting OSS components for integration.*
- *For successful GSD projects, practitioners should consider their adoption context of OSS development and take informed decisions in order to know the underpinning benefits and drawbacks.*

These practical recommendations regarding OSS development in global software development organizations allow GSD project managers to make informed decisions on implementing OSS development that will potentially improve the successful development and deployment of projects in GSD organizations.

CHAPTER 6

LIMITATIONS AND CONCLUSIONS

6.1 Limitations and Future directions

This research study has its limitations. In both of our case studies such as globally distributed CBS development and globally distributed OSS development, one major limitation is the sample size used. The more we could have large sample, the more we could be able to predict the mean closer to the true value of population. This indicates that our study reflect very little due to very small sample size. Therefore, the proposed research models can be evaluated with a large sample data for additional research on globally distributed software development practices in GSD organizations. Second limitation is that our questionnaire survey was limited to specific places such as Asia and Australia. This means the results of our research study reflect the behaviors of these places only. Researchers can empirically investigate the determinants of the adoption of globally software development practices in other countries and can provide a comparative research study. Moreover, researchers can also consider an empirically investigation study in other countries by using our research models.

Another possible limitation is construct threat (validity) as innovation adoption studies may use inappropriate latent variables. In our case, we tried to minimize the construct threat through empirical evidence found in the published literature for supporting determinants. One other possible limitation of survey-based study is internal threat (validity). In our case, we tried to minimize the internal threat by allowing only related degree holders. Similarly, another possible limitation is external threat (validity), therefore, we tried to minimize the external validity by snowballing sampling technique and boot-straping method to have a true random sample. Researchers can further apply other techniques for true random sampling in order to more minimize the external threat.

One other possible limitation is the number of determinants that we have considered for this research study, as there is possibility of more determinants that could explain the adoption of globally distributed CBS development and globally distributed OSS development in a more holistic manner. Therefore, researchers can add other determinants such as firm size, degree of centralization, and regulatory support in terms of adding research to understanding the determinants of globally distributed software development from an organization perspective. Another limitation can be the context of the CBS development methodology and OSS development methodology. We might have define it very narrow and loose. So other contexts such as CBS and OSS as a whole system can be add to extend the research models in hand. This will help in refinement of the research models to further investigate about the adoption of globally distributed CBS development and globally distributed OSS development. Lastly, the proposed research models can be further evaluated not only for the adoption stage but also for pre-adoption stage (persuasion stage) and post-adoption stage (routinization stage), which could be an interesting research direction.

6.2 Conclusions

Globally distributed organizations with an increased interest in globally distributed CBS development methodology presume different benefits such as reuse of components, better quality of software, reduction in development costs by the extensive use of quality components and have adopted globally distributed OSS development methodology to obtain different advantages such as reliability, cost savings, reduction in time-to-market, rapid responses to user requests, community contribution, increase in quality software, and fast improvements from the diffusion of globally distributed CBS development and globally distributed OSS development adoption. This research study investigates the effects both direct and indirect of determinants that influence the adoption of globally distributed

CBS development and globally distributed OSS development in global context. The investigation of the effects of determinants is twofold: (1) the evaluation of direct effects of the constructs; (2) the evaluation total effects of the constructs such as direct and indirect effects. Therefore, the results of the investigation help in understanding the determinants and its relative advantage to globally distributed organizations.

Furthermore, in this research study we have created two integrative conceptual research models that is a combination of two well known adoption theories: (1) DOI theory [77], that explains the diffusion process of globally distributed CBS development and globally distributed OSS development by its innovation characteristics; (2) TOE framework [40], that explains the cause of GD CBS development and GD OSS development adoption by its three contextual perspectives such as technology, organization, and environment contexts. Therefore, the investigation of factors is based on innovation characteristics and technological, organizational, and environmental perspectives of globally distributed organizations. Furthermore, the empirical evaluations of the conceptual research models are performed through two samples of 115 respondents in case of globally distributed CBS development and 198 respondents in case of globally distributed OSS development both from Asia and Australia.

The empirical results confirm the direct effects of relative advantage, complexity, technology competence, and top management support on adoption of CBS development practice and relative advantage, complexity, technology readiness, top management support, and competitive pressure on adoption of OSS development practice in globally distributed organizations. In case of globally distributed CBS development, the results also confirm the direct effects of development cost and integration cost on the relative advantage of GD CBS development adoption and the indirect effects of development cost and integration cost on GD CBS development adoption. In case of globally distributed OSS development, the results also confirm the direct effects of time saving and cost savings on the relative advantage of GD OSS development adoption and the indirect effects of time saving and cost savings on GD OSS development adoption.

The findings are important to keep in the literature for other studies that would like to evaluate the adoption of GD CBS development methodology and GD OSS development methodology in globally distributed organizations. The study shows that evaluating new technologies for their adoption such as the adoption of globally distributed CBS development and globally distributed OSS development, a systematic approach that combines the innovation characteristics of the adopting innovation and technological, organizational, and environmental perspectives of the organization is trustworthy in explaining the perceptions to researchers and practitioners. Hence, our approach is more holistic in investigating the determinants of adopting globally distributed CBS development and globally distributed OSS development in global context.

REFERENCES

[1] M. A. Khan and S. Mahmood, "A graph based requirements clustering approach for component selection," *Advances in Engineering Software*, vol. 54, pp. 1–16, 2012.

[2] S. Mahmood, R. Lai, and Y. S. Kim, "Survey of component-based software development," *IET software*, vol. 1, no. 2, pp. 57–66, 2007.

[3] K. Crowston, "Open source technology development," *Handbook of science and technology convergence. Springer, Berlin*, pp. 475–486, 2016.

[4] M. Niazi, S. Mahmood, M. Alshayeb, A. M. Qureshi, K. Faisal, and N. Cerpa, "Toward successful project management in global software development," *International Journal of Project Management*, vol. 34, no. 8, pp. 1553–1567, 2016.

[5] S. Mahmood and A. Khan, "An industrial study on the importance of software component documentation: A system integrator's perspective," *Information Processing Letters*, vol. 12, pp. 583–590, 2011.

[6] S. Weber, *The success of open source.* Cambridge Univ Press, 2004, vol. 368.

[7] T. Kern and L. Willcocks, "Exploring information technology outsourcing relationships: Theory and practice," *Journal of Strategic Information Systems*, vol. 9, pp. 321–350, 2000.

[8] J. Kotlarsky and I. Oshri, *Managing component-based development in global teams.* Springer, 2009.

[9] S. Mahmood, M. Niazi, and A. Hussain, "Identifying the challenges for managing component-based development in global software development: Preliminary results," in *Science and Information Conference (SAI), 2015.* IEEE, 2015, pp. 933–938.

[10] S. Sharma, V. Sugumaran, and B. Rajagopalan, "A framework for creating hybrid-open source software communities," *Information Systems Journal*, vol. 12, no. 1, pp. 7–25, 2002.

[11] K.-J. Stol and M. A. Babar, "Reporting empirical research in open source software: the state of practice," in *IFIP International Conference on Open Source Systems.* Springer, 2009, pp. 156–169.

[12] D. Spinellis, "Global software development in the freebsd project," in *Proceedings of the 2006 international workshop on Global software development for the practitioner.* ACM, 2006, pp. 73–79.

[13] C. P. Ayala, D. Cruzes, O. Hauge, and R. Conradi, "Five facts on the adoption of open source software," *IEEE software*, vol. 28, no. 2, pp. 95–99, 2011.

[14] M. R. J. Qureshi and S. Hussain, "A reusable software component-based development process model," *Advances in engineering software*, vol. 39, no. 2, pp. 88–94, 2008.

[15] P. Vitharana, "Risks and challenges of component-based software development," *Communications of the ACM*, vol. 46, no. 8, pp. 67–72, 2003.

[16] J. Maras, M. Stula, and I. Crnkovic, "Towards specifying pragmatic software reuse," in *Proceedings of the 2015 European Conference on Software Architecture Workshops*. ACM, 2015, p. 54.

[17] L. Bass, C. Buhman, S. Comella-Dorda, F. Long, and J. Robert, "Volume 1: Market assessment of component-based software engineering," DTIC Document, Tech. Rep., 2000.

[18] J. Kotlarsky, *Management of globally distributed component-based software development projects*, 2005.

[19] M. S. Andreasen, H. V. Nielsen, S. O. Schrøder, and J. Stage, "Usability in open source software development: Opinions and practice," *Information technology and control*, vol. 35, no. 3, 2015.

[20] G. Von Krogh, "Open-source software development," *MIT Sloan Management Review*, vol. 44, no. 3, p. 14, 2003.

[21] M. Rajanen and N. Iivari, "Examining usability work and culture in oss," in *IFIP International Conference on Open Source Systems.* Springer, 2015, pp. 58–67.

[22] M. AlMarzouq, L. Zheng, G. Rong, and V. Grover, "Open source: Concepts, benefits, and challenges," *Communications of the Association for Information Systems*, vol. 16, no. 1, p. 37, 2005.

[23] N. Choi and J. A. Pruett, "The characteristics and motivations of library open source software developers: An empirical study," *Library & Information Science Research*, vol. 37, no. 2, pp. 109–117, 2015.

[24] Ø. Hauge, C. Ayala, and R. Conradi, "Adoption of open source software in software-intensive organizations–a systematic literature review," *Information and Software Technology*, vol. 52, no. 11, pp. 1133–1154, 2010.

[25] S. A. Ajila and D. Wu, "Empirical study of the effects of open source adoption on software development economics," *Journal of Systems and Software*, vol. 80, no. 9, pp. 1517–1529, 2007.

[26] D. Yakimovich, J. M. Bieman, and V. R. Basili, "Software architecture classification for estimating the cost of cots integration," in *Software Engineering, 1999. Proceedings of the 1999 International Conference on.* IEEE, 1999, pp. 296–302.

[27] I. Crnkovic, "Component-based software engineeringnew challenges in software development," *Software Focus*, vol. 2, no. 4, pp. 127–133, 2001.

[28] A. Kaur and K. S. Mann, "Component selection for component based software engineering," *International Journal of Computer Applications*, vol. 2, no. 1, pp. 109–114, 2010.

[29] C. Alves and A. Finkelstein, "Investigating conflicts in cots decision-making," *International Journal of Software Engineering and Knowledge Engineering*, vol. 13, no. 05, pp. 473–493, 2003.

[30] H. Holmstrom, E. Ó. Conchúir, J. Agerfalk, and B. Fitzgerald, "Global software development challenges: A case study on temporal, geographical and socio-cultural distance," in *2006 IEEE International Conference on Global Software Engineering (ICGSE'06)*. IEEE, 2006, pp. 3–11.

[31] J. Kotlarsky, "Re-engineering at lecroy corporation: the move to component-based systems," *Journal of Information Technology*, vol. 22, no. 4, pp. 465–478, 2007.

[32] G. T. Heineman and W. T. Councill, "Component-based software engineering," *Putting the pieces together, addison-westley*, p. 5, 2001.

[33] O.-K. D. Lee, P. Banerjee, K. H. Lim, K. Kumar, J. v. Hillegersberg, and K. K. Wei, "Aligning it components to achieve agility in globally distributed system development," *Communications of the ACM*, vol. 49, no. 10, pp. 48–54, 2006.

[34] P. J. Ågerfalk, B. Fitzgerald, H. H. Olsson, and E. Ó. Conchúir, "Benefits of global software development: the known and unknown," in *International Conference on Software Process*. Springer, 2008, pp. 1–9.

[35] J. C. Huang, S. Newell, R. D. Galliers, and S.-L. Pan, "Dangerous liaisons? component-based development and organizational subcultures," *Global information systems: the implications of culture for IS management*, pp. 202–226, 2008.

[36] J. M. Kotlarsky, K. Kumar, and J. Hillegersberg, "Coordination and collaboration for globally distributed teams: the case of componentbased/object-oriented software development," in *Proceedings of International Workshop on Global Software Development (ICSE 2002)*, 2002.

[37] J. Kotlarsky and I. Oshri, "Social ties, knowledge sharing and successful collaboration in globally distributed system development projects," *European Journal of Information Systems*, vol. 14, no. 1, pp. 37–48, 2005.

[38] J. Kotlarsky, I. Oshri, J. van Hillegersberg, and K. Kumar, "Globally distributed component-based software development: an exploratory study of knowledge management and work division," *Journal of Information Technology*, vol. 22, no. 2, pp. 161–173, 2007.

[39] E. M. Rogers, "Elements of diffusion," *Diffusion of innovations*, vol. 5, pp. 1–38, 2003.

[40] L. G. Tornatzky, M. Fleischer, and A. K. Chakrabarti, *Processes of technological innovation.* Lexington Books, 1990.

[41] E. Glynn, B. Fitzgerald, and C. Exton, "Commercial adoption of open source software: an empirical study," in *2005 International Symposium on Empirical Software Engineering, 2005.* IEEE, 2005, pp. 10–pp.

[42] C. Gutwin, R. Penner, and K. Schneider, "Group awareness in distributed software development," in *Proceedings of the 2004 ACM conference on Computer supported cooperative work.* ACM, 2004, pp. 72–81.

[43] M. S. Elliott and W. Scacchi, "Free software developers as an occupational community: resolving conflicts and fostering collaboration," in *Proceedings of the 2003 international ACM SIGGROUP conference on Supporting group work.* ACM, 2003, pp. 21–30.

[44] J.-P. Van Belle and M. Reed, "Oss adoption in south africa: Applying the toe model to a case study," in *IFIP International Conference on Open Source Systems.* Springer, 2012, pp. 304–309.

[45] T. Przechlewski and K. Strzała, "Determinants of open source software adoption–an application of toe framework," in *Information Systems Development.* Springer, 2009, pp. 461–469.

[46] J. Dedrick and J. West, "An exploratory study into open source platform adoption," in *System Sciences, 2004. Proceedings of the 37th Annual Hawaii International Conference on.* IEEE, 2004, pp. 10–pp.

[47] C. M. Ringle, S. Wende, and J.-M. Becker, "Smartpls 3," *Boenningstedt: SmartPLS GmbH, http://www. smartpls. com*, 2015.

[48] I. Oshri, J. Kotlarsky, and L. P. Willcocks, "Global software development: Exploring socialization and face-to-face meetings in distributed strategic projects," *The Journal of Strategic Information Systems*, vol. 16, no. 1, pp. 25–49, 2007.

[49] M. Niazi, S. Mahmood, M. Alshayeb, A. Qureshi, K. Faisal, and N. Cerpa, "Towards indentifying the factors for project management success in global software development: Initial results," in *Proceedings of the Eigth International Conference on Software Engineering Advances*, 2013, pp. 285–290.

[50] R. Britto, E. Mendes, and J. Börstler, "An empirical investigation on effort estimation in agile global software development," in *Global Software Engineering (ICGSE), 2015 IEEE 10th International Conference on.* IEEE, 2015, pp. 38–45.

[51] A. Yague, J. Garbajosa, J. Dıaz, and E. Gonzalez, "Global software development," 2016.

[52] L. McLaughlin, "An eye on india: Outsourcing debate continues," *Ieee Software*, vol. 20, no. 3, pp. 114–117, 2003.

[53] P. J. Agerfalk, B. Fitzgerald, H. Holmstrom Olsson, B. Lings, B. Lundell, and E. Ó Conchúir, "A framework for considering opportunities and threats in distributed software development," 2005.

[54] S. R. Jan, F. Dad, N. Amin, A. Hameed, and S. S. A. Shah, "Issues in global software development (communication, coordination and trust) a critical review," *training*, vol. 6, no. 7, p. 8, 2016.

[55] A. Nguyen-Duc, D. S. Cruzes, and R. Conradi, "The impact of global dispersion on coordination, team performance and software quality–a systematic literature review," *Information and Software Technology*, vol. 57, pp. 277–294, 2015.

[56] M. Niazi, S. Mahmood, M. Alshayeb, M. R. Riaz, K. Faisal, N. Cerpa, S. U. Khan, and I. Richardson, "Challenges of project management in global software development: A client-vendor analysis," *Information and Software Technology*, vol. 80, pp. 1–19, 2016.

[57] D. Damian, L. Izquierdo, J. Singer, and I. Kwan, "Awareness in the wild: Why communication breakdowns occur," in *International Conference on Global Software Engineering (ICGSE 2007)*. IEEE, 2007, pp. 81–90.

[58] J. Kotlarsky, I. Oshri, P. Van Fenema, and P. Van Fenema, *Knowledge processes in globally distributed contexts*. Springer, 2008.

[59] R. Szendrei, "Component-based software development," 2015.

[60] A. T. Quadri, M. Abubakar, and M. Sirshar, "Software quality assurance in component based software developmenta survey analysis," *International Journal of Computer and Communication System Engineering*, vol. 2, no. 2, pp. 305–315, 2015.

[61] J. C. Huang, S. Newell, R. D. Galliers, and S.-L. Pan, “Dangerous liaisons? component-based development and organizational subcultures,” *IEEE Transactions on Engineering Management*, vol. 50, no. 1, pp. 89–99, 2003.

[62] C. Ebert, “Guest editor's introduction: how open source tools can benefit industry,” *IEEE software*, vol. 26, no. 2, pp. 50–51, 2009.

[63] A. Bonaccorsi and C. Rossi, “Comparing motivations of individual programmers and firms to take part in the open source movement: From community to business,” *Knowledge, Technology & Policy*, vol. 18, no. 4, pp. 40–64, 2006.

[64] L. Morgan and P. Finnegan, “Benefits and drawbacks of open source software: an exploratory study of secondary software firms,” in *IFIP International Conference on Open Source Systems*. Springer, 2007, pp. 307–312.

[65] C. Ruffin and C. Ebert, “Using open source software in product development: A primer,” *IEEE software*, vol. 21, no. 1, pp. 82–86, 2004.

[66] L. Llerena, N. Rodríguez, J. W. Castro, and S. T. Acuña, “Adoption of the user profiles technique in the open source software development process,” in *International Conference on Software Process Improvement*. Springer, 2016, pp. 201–210.

[67] B. Fitzgerald, “The transformation of open source software,” *Mis Quarterly*, pp. 587–598, 2006.

[68] B. Großer and U. Baumöl, "Business-driven open source software development," in *International Conference on Business Informatics Research*. Springer, 2016, pp. 122–129.

[69] K. Crowston and J. Howison, "The social structure of free and open source software development," *First Monday*, vol. 10, no. 2, 2005.

[70] I. Stamelos, L. Angelis, A. Oikonomou, and G. L. Bleris, "Code quality analysis in open source software development," *Information Systems Journal*, vol. 12, no. 1, pp. 43–60, 2002.

[71] M. A. Babar, J. M. Verner, and P. T. Nguyen, "Establishing and maintaining trust in software outsourcing relationships: An empirical investigation," *Journal of Systems and Software*, vol. 80, no. 9, pp. 1438–1449, 2007.

[72] S. M. Easterbrook, E. E. Beck, J. S. Goodlet, L. Plowman, M. Sharples, and C. C. Wood, "A survey of empirical studies of conflict," in *CSCW: Cooperation or Conflict?* Springer, 1993, pp. 1–68.

[73] S. S. Levine and M. J. Prietula, "Open collaboration for innovation: principles and performance," *Organization Science*, 2013.

[74] H. Plotkin, "What (and why) you should know about open source software," *Harvard Management Update*, vol. 12, pp. 3–4, 1998.

[75] J. Feller and B. Fitzgerald, "A framework analysis of the open source software development paradigm," in *Proceedings of the twenty first international*

conference on Information systems. Association for Information Systems, 2000, pp. 58–69.

[76] J. D. Herbsleb and R. E. Grinter, "Architectures, coordination, and distance: Conway's law and beyond," *IEEE software*, vol. 16, no. 5, pp. 63–70, 1999.

[77] E. M. Rogers, *Diffusion of innovations.* Simon and Schuster, 2010.

[78] I. Ajzen, "The theory of planned behavior," *Organizational behavior and human decision processes*, vol. 50, no. 2, pp. 179–211, 1991.

[79] F. D. Davis Jr, "A technology acceptance model for empirically testing new end-user information systems: Theory and results," Ph.D. dissertation, Massachusetts Institute of Technology, 1986.

[80] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," *MIS quarterly*, pp. 425–478, 2003.

[81] S. Shah Alam, "Adoption of internet in malaysian smes," *Journal of Small Business and Enterprise Development*, vol. 16, no. 2, pp. 240–255, 2009.

[82] C. A. Mora-Monge, A. Azadegan, and J. Teich, "Effective benchmarking of innovation adoptions: A theoretical framework for e-procurement technologies," *Benchmarking: An International Journal*, vol. 17, no. 4, pp. 472–490, 2010.

[83] K. Zhu, S. Dong, S. X. Xu, and K. L. Kraemer, "Innovation diffusion in global contexts: determinants of post-adoption digital transformation of european companies," *European journal of information systems*, vol. 15, no. 6, pp. 601–616, 2006.

[84] P. Ifinedo, "An empirical analysis of factors influencing internet/e-business technologies adoption by smes in canada," *International Journal of Information Technology & Decision Making*, vol. 10, no. 04, pp. 731–766, 2011.

[85] T. R. Leinbach, "Global e-commerce: Impacts of national environment and policy, edited by kenneth l. kraemer, jason dedrick, nigel p. melville, and kevin zhu. cambridge: Cambridge university press, 2006. xxii+ 444 pp. 75.00 cloth. isbn 0-521-84822-9," 2008.

[86] T. Oliveira, M. Thomas, and M. Espadanal, "Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors," *Information & Management*, vol. 51, no. 5, pp. 497–510, 2014.

[87] T. Oliveira and M. F. Martins, "Information technology adoption models at firm level: review of literature," in *European Conference on Information Management and Evaluation.* Academic Conferences International Limited, 2010, p. 312.

[88] M. K. Sharma, "Receptivity of india's small and medium-sized enterprises to information system adoption," *Enterprise Information Systems*, vol. 3, no. 1, pp. 95–115, 2009.

[89] R. Martins, T. Oliveira, and M. A. Thomas, "An empirical analysis to assess the determinants of saas diffusion in firms," *Computers in Human Behavior*, vol. 62, pp. 19–33, 2016.

[90] K. Zhu, K. L. Kraemer, and S. Xu, "The process of innovation assimilation by firms in different countries: a technology diffusion perspective on e-business," *Management science*, vol. 52, no. 10, pp. 1557–1576, 2006.

[91] A. Y.-L. Chong and F. T. Chan, "Structural equation modeling for multi-stage analysis on radio frequency identification (rfid) diffusion in the health care industry," *Expert Systems with Applications*, vol. 39, no. 10, pp. 8645–8654, 2012.

[92] S. K. Lippert and C. Govindarajulu, "Technological, organizational, and environmental antecedents to web services adoption," *Communications of the IIMA*, vol. 6, no. 1, p. 14, 2015.

[93] T. Oliveira and M. F. Martins, "Understanding e-business adoption across industries in european countries," *Industrial Management & Data Systems*, vol. 110, no. 9, pp. 1337–1354, 2010.

[94] Y. Zhu, Y. Li, W. Wang, and J. Chen, "What leads to post-implementation success of erp? an empirical study of the chinese retail industry," *International Journal of Information Management*, vol. 30, no. 3, pp. 265–276, 2010.

[95] P. Y. Chau and K. Y. Tam, "Factors affecting the adoption of open systems: an exploratory study," *MIS quarterly*, pp. 1–24, 1997.

[96] K. Zhu and K. L. Kraemer, "Post-adoption variations in usage and value of e-business by organizations: cross-country evidence from the retail industry," *Information systems research*, vol. 16, no. 1, pp. 61–84, 2005.

[97] K. Zhu, K. Kraemer, and S. Xu, "Electronic business adoption by european firms: a cross-country assessment of the facilitators and inhibitors," *European Journal of Information Systems*, vol. 12, no. 4, pp. 251–268, 2003.

[98] F. Thiesse, T. Staake, P. Schmitt, and E. Fleisch, "The rise of the next-generation bar code: an international rfid adoption study," *Supply Chain Management: An International Journal*, vol. 16, no. 5, pp. 328–345, 2011.

[99] K. Lyytinen and J. Damsgaard, "Inter-organizational information systems adoption–a configuration analysis approach," *European journal of information systems*, vol. 20, no. 5, pp. 496–509, 2011.

[100] R. G. Fichman, "Going beyond the dominant paradigm for information technology innovation research: Emerging concepts and methods," *Journal of the association for information systems*, vol. 5, no. 8, p. 11, 2004.

[101] Y. Wu, C. G. Cegielski, B. T. Hazen, and D. J. Hall, "Cloud computing in support of supply chain information system infrastructure: understanding when to go to the cloud," *Journal of Supply Chain Management*, vol. 49, no. 3, pp. 25–41, 2013.

[102] C. Low, Y. Chen, and M. Wu, "Understanding the determinants of cloud computing adoption," *Industrial management & data systems*, vol. 111, no. 7, pp. 1006–1023, 2011.

[103] P.-F. Hsu, K. L. Kraemer, and D. Dunkle, "Determinants of e-business use in us firms," *International Journal of Electronic Commerce*, vol. 10, no. 4, pp. 9–45, 2006.

[104] A. Alkhalil, R. Sahandi, and D. John, "An exploration of the determinants for decision to migrate existing resources to cloud computing using an integrated toe-doi model," *Journal of Cloud Computing*, vol. 6, no. 1, p. 2, 2017.

[105] C.-Y. Chiu, S. Chen, and C.-L. Chen, "An integrated perspective of toe framework and innovation diffusion in broadband mobile applications adoption by enterprises," *International Journal of Management, Economics and Social Sciences (IJMESS)*, vol. 6, no. 1, pp. 14–39, 2017.

[106] M. A. Alomar and C. de Visscher, "Which factors can affect e-public procurement adoption by private firms? the case of belgium." *Electronic Journal of e-Government*, vol. 15, no. 2, 2017.

[107] A. Quinting, S. Lins, J. Szefer, and A. Sunyaev, "Advancing the adoption of a new generation of certifications–a theoretical model to explain the adoption of continuous cloud service certification by certification authorities," *Proceedings of Wirtschaftsinformatik (WI 2017)*, pp. 1–12, 2017.

[108] M. Thomas, D. Costa, and T. Oliveira, "Assessing the role of it-enabled process virtualization on green it adoption," *Information Systems Frontiers*, vol. 18, no. 4, pp. 693–710, 2016.

[109] Y. K. Dwivedi, A. Papazafeiropoulo, B. Ramdani, P. Kawalek, and O. Lorenzo, "Predicting smes' adoption of enterprise systems," *Journal of Enterprise Information Management*, vol. 22, no. 1/2, pp. 10–24, 2009.

[110] A. Y.-L. Chong, B. Lin, K.-B. Ooi, and M. Raman, "Factors affecting the adoption level of c-commerce: An empirical study," *Journal of Computer Information Systems*, vol. 50, no. 2, pp. 13–22, 2009.

[111] R. Klein, "Assimilation of internet-based purchasing applications within medical practices," *Information & Management*, vol. 49, no. 3, pp. 135–141, 2012.

[112] M.-C. Tsai, W. Lee, and H.-C. Wu, "Determinants of rfid adoption intention: Evidence from taiwanese retail chains," *Information & Management*, vol. 47, no. 5, pp. 255–261, 2010.

[113] C. A. De Mattos and F. J. B. Laurindo, "Information technology adoption and assimilation: Focus on the suppliers portal," *Computers in Industry*, vol. 85, pp. 48–57, 2017.

[114] S. Faber, M. van Geenhuizen, and M. de Reuver, "ehealth adoption factors in medical hospitals: A focus on the netherlands," *International Journal of Medical Informatics*, vol. 100, pp. 77–89, 2017.

[115] Y.-S. Wang, H.-T. Li, C.-R. Li, and D.-Z. Zhang, "Factors affecting hotels' adoption of mobile reservation systems: A technology-organization-environment framework," *Tourism Management*, vol. 53, pp. 163–172, 2016.

[116] M. Ghobakhloo, D. Arias-Aranda, and J. Benitez-Amado, "Adoption of e-commerce applications in smes," *Industrial Management & Data Systems*, vol. 111, no. 8, pp. 1238–1269, 2011.

[117] H.-F. Lin and S.-M. Lin, "Determinants of e-business diffusion: A test of the technology diffusion perspective," *Technovation*, vol. 28, no. 3, pp. 135–145, 2008.

[118] M. Lumpe, "Gloo: a framework for modeling and reasoning about component-oriented language abstractions," in *International Symposium on Component-Based Software Engineering*. Springer, 2006, pp. 17–32.

[119] L. Seinturier, N. Pessemier, L. Duchien, and T. Coupaye, "A component model engineered with components and aspects," in *International Symposium on Component-Based Software Engineering*. Springer, 2006, pp. 139–153.

[120] R. Kadri, F. Merciol, and S. Sadou, "Cbse in small and medium-sized enterprise: Experience report," in *International Symposium on Component-Based Software Engineering*. Springer, 2006, pp. 154–165.

[121] V. Grassi, R. Mirandola, and A. Sabetta, "A model transformation approach for the early performance and reliability analysis of component-based

systems," in *International Symposium on Component-Based Software Engineering*. Springer, 2006, pp. 270–284.

[122] C. J. Reynolds and J. C. Wyatt, "Open source, open standards, and health care information systems," *Journal of medical Internet research*, vol. 13, no. 1, p. e24, 2011.

[123] Ø. Hauge, C.-F. Sørensen, and R. Conradi, "Adoption of open source in the software industry," in *IFIP International Conference on Open Source Systems*. Springer, 2008, pp. 211–221.

[124] T. Greenhalgh, G. Robert, F. Macfarlane, P. Bate, and O. Kyriakidou, "Diffusion of innovations in service organizations: systematic review and recommendations," *Milbank Quarterly*, vol. 82, no. 4, pp. 581–629, 2004.

[125] S. Kumari and S. Pushkar, "Performance analysis of the software cost estimation methods: a review," *International Journal of Advanced Research in Computer Science and Software Engineering*, vol. 3, no. 7, 2013.

[126] S. Chong and C. Bauer, "A model of factor influences on electronic commerce adoption and diffusion in small-and medium-sized enterprises," *PACIS 2000 Proceedings*, p. 23, 2000.

[127] R. D. Macredie and K. Mijinyawa, "A theory-grounded framework of open source software adoption in smes," *European Journal of Information Systems*, vol. 20, no. 2, pp. 237–250, 2011.

[128] S. Mahmood, S. Anwer, M. Niazi, M. Alshayeb, and I. Richardson, "Identifying the factors that influence task allocation in global software development: preliminary results," in *Proceedings of the 19th International Conference on Evaluation and Assessment in Software Engineering.* ACM, 2015, p. 31.

[129] T. L. Doolen, M. E. Hacker, and E. M. Van Aken, "The impact of organizational context on work team effectiveness: A study of production team," *IEEE Transactions on Engineering Management*, vol. 50, no. 3, pp. 285–296, 2003.

[130] B. J. Weiner, "A theory of organizational readiness for change," *Implementation Science*, vol. 4, no. 1, p. 1, 2009.

[131] S. L. Pfleeger and B. A. Kitchenham, "Principles of survey research: part 1-6," *ACM SIGSOFT Software Engineering Notes*, vol. 26, no. 6, pp. 16–18, 2001.

[132] S. S. Alam, M. Y. Ali, M. F. M. Janic *et al.*, "An empirical study of factors affecting electronic commerce adoption among smes in malaysia," *Journal of Business Economics and Management*, vol. 12, no. 2, pp. 375–399, 2011.

[133] P. Ifinedo, "Internet/e-business technologies acceptance in canada's smes: an exploratory investigation," *Internet Research*, vol. 21, no. 3, pp. 255–281, 2011.

[134] P. Chwelos, I. Benbasat, and A. S. Dexter, "Research report: Empirical test of an edi adoption model," *Information systems research*, vol. 12, no. 3, pp. 304–321, 2001.

[135] T. Oliveira and M. F. Martins, "Firms patterns of e-business adoption: evidence for the european union-27," *The Electronic Journal Information Systems Evaluation*, vol. 13, no. 1, pp. 47–56, 2010.

[136] J. Henseler, C. M. Ringle, and R. R. Sinkovics, "The use of partial least squares path modeling in international marketing," in *New challenges to international marketing.* Emerald Group Publishing Limited, 2009, pp. 277–319.

[137] J. F. Hair, C. M. Ringle, and M. Sarstedt, "Pls-sem: Indeed a silver bullet," *Journal of Marketing theory and Practice*, vol. 19, no. 2, pp. 139–152, 2011.

[138] C. Fornell and D. F. Larcker, "Evaluating structural equation models with unobservable variables and measurement error," *Journal of marketing research*, pp. 39–50, 1981.

[139] W. W. Chin, "Issues and opinions on structural equation modeling," 2003.

[140] H. Wang and C. Wang, "Open source software adoption: A status report," *IEEE Software*, vol. 18, no. 2, pp. 90–95, 2001.

[141] C. L. Iacovou, I. Benbasat, and A. S. Dexter, "Electronic data interchange and small organizations: Adoption and impact of technology," *MIS quarterly*, pp. 465–485, 1995.

[142] L. G. Tornatzky and K. J. Klein, "Innovation characteristics and innovation adoption-implementation: A meta-analysis of findings," *IEEE Transactions on engineering management*, no. 1, pp. 28–45, 1982.

[143] J. Asundi, "Software engineering lessons from open source projects," in *Proceedings of the 1st Workshop on Open Source Software Engineering, Toronto, ON, Canada*, 2001.

[144] V. Grover, M. J. Cheon, and J. T. Teng, "The effect of service quality and partnership on the outsourcing of information systems functions," *Journal of Management Information Systems*, vol. 12, no. 4, pp. 89–116, 1996.

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