Blockchain Technology Adoption in Saudi Arabia’s Higher Education Sector

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Doctor of Philosophy

under the supervision of
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Certificate of Original Authorship

I, Mohrah Alalyan, declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

Signature: Mohrah Alalyan

Date: 08/08/2023

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وَقُلْ رَبِّ زِدْنِي عِلْمًا

And say: 'My Lord, increase me in knowledge' (Quran 20:114)

With the words transcribed above, I thank Allah, the Most Beneficent, the Most Merciful, who has bestowed upon me countless blessings and has made this journey possible. Without His grace and guidance, I would not have been able to achieve this milestone in my academic career.

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List of Abbreviations

AVE	Average Variance Extracted
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CITC	Corrected Item Total Correlation
DOI	Diffusion of Innovations
EFA	Exploratory Factor Analysis
GCC	Gulf Cooperation Council
HEI	Higher Education Institution
ICT	Information and Communication Technologies
IT	Information Technology
KAUST	King Abdullah University of Science and Technology
KSA	Kingdom of Saudi Arabia
MHE	Ministry of Higher Education
MOE	Ministry of Education
NFI	Normed Fit Index
OECD	Organisation for Economic Co-operation and Development
PEOU	Perceived Ease of Use
PU	Perceived Usefulness
RMSEA	Root Mean Square Error of Approximation
SAMA	Saudi Arabia Monetary Agency
SCT	Social Cognitive Theory
SEM	Structural Equation Modelling
SLR	Systematic (Structured) Literature Review
SRMR	Square Root Mean Residual
TAM	Technology Acceptance Model
TLI	Tucker-Lewis Index
TOE	Technology-Organisation-Environment Framework
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TTF	Task-Technology Fit
TVTC	Technical and Vocational Training Corporation
UTAUT	Unified Theory of Acceptance and Use of Technology
VIF	Variance Inflation Factor

Abstract

Blockchain technology is a decentralised, digital ledger that records transactions in a secure and transparent way using cryptography. It allows for a trustless system where no central authority is needed to validate transactions. Originally used as a cryptocurrency mechanism, blockchain has since found applications in many fields and industries, although its applications in education are still emerging.

Guided by 1) the importance assigned to innovative technologies for higher education development in Saudi Arabia and 2) the lack of blockchain adoption knowledge in this field, this study aims to develop a framework for blockchain adoption in Saudi higher education institutions.

Using the Design Science Approach as a basis, this study 1) designs an original framework based on theoretical and empirical literature on blockchain adoption; 2) presents the results of the framework analysis and refinement by industry experts; and 3) demonstrates the results of the framework evaluation based on a large-scale survey of higher education professionals.

The Blockchain Adoption Framework for Saudi Higher Education Institutions developed in this study is, to the best knowledge of the researcher, the first of its kind. It includes five dimensions: Technology, Organisation, Environment, Quality and Barriers. The model demonstrates a high level of validity with 11 out of 16 factors demonstrating a statistically significant relationship to blockchain adoption. The framework can serve as a practical tool for institutional decision makers in developing a plan for blockchain adoption in colleges and universities in Saudi Arabia. The framework is supplemented with a questionnaire tool that helps identify adoption enablers and barriers specific to each institution. The framework can also be used as a foundation for further research on blockchain adoption both in the context of higher education and related industries.

Despite its rigorous research approach, the study still had some limitations regarding geographic and industry context, data collection and sampling methods. Therefore, future studies are recommended to explore the framework's applicability to other sectors and national contexts as well as using different methodologies to test its validity.

1 Introduction

1.1 Chapter Summary

This chapter provides an overview of the research background and context as well as its importance and contribution to the existing knowledge. Section 1.2 offers the study background: it discusses the importance of the educational sector for national development and the role of technological innovations in this process. Specific references are made to the role of blockchain as an emergent technology for education. Section 1.3 reviews the research context – the higher education sector in Saudi Arabia. Section 1.4 provides a brief review of blockchain technology and its potential for education is provided. Section 1.5 identifies the research significance and contribution. In Section 1.6, the research outline is presented and visualised.

1.2 Background

The educational sector plays an important role in any country's development. This is particularly true for countries which are looking for economic diversification and tapping into their enormous human potential. For Saudi Arabia, the development of education, in particular higher education, has become one of the major goals of the consequent Development Plans starting from the 1970s (Allahmorad & Zreik, 2020). The primary national development document, Vision 2030, assigns higher education one of the key roles in turning Saudi Arabia to a major global force within the upcoming decade.

Historically, the developments in the educational sector have been increasingly seen alongside technological progress (Bernacki, Greene, & Crompton, 2020; Ratheeswari, 2018). Indeed, technology is often seen as a disruptive force in all aspects of education: from the new approaches in providing learning content to administration and control over education processes (Selwyn, 2012). In different periods of time, both researchers and practitioners have examined the impact on education by at-the-time novel technologies such as mobile networks, cloud computing, virtual reality, and the Internet-of-Things (Al-Emran, Malik, & Al-Kabi, 2020; Ercan, 2010; Eschenbrenner & Nah, 2007; Hedburg & Alexander, 1994). Both the transformative impact and practical applications of these technologies for education purposes are well reported in literature.

Given the importance of integrating novel technologies into higher education, administrators and IT specialists in colleges and universities are likely to explore the opportunities and challenges in applying these technologies within their organizations. Many different factors may be in play in this case including, but not limited to, the technology itself and its potential to improve organisational processes; the organisational structures and existing operational frameworks; the human resources that the organization possesses; and the environment in which the organization operates. It is important to understand the influence of these factors to understand both the process of new technology adoption and its potential to benefit the educational organization.

One of the emerging technologies with a high potential for education today is blockchain. Introduced primarily as a decentralised cryptocurrency tool (Nakamoto, 2008), blockchain received widespread attention since Buterin's (2014) ground-breaking paper which described its many possible applications in different areas of life. Within only a few years, blockchain applications found their way into various industries, although practical implementations in many of them remain in their infancy (Grover, Kar, & Janssen, 2019). The higher education sector is not an exception in this case. Whereas researchers identified numerous potential uses of blockchain to contribute to educational institutions' value chains (e.g., (Alammary, Alhazmi, Almasri, & Gillani, 2019; Awaji, Solaiman, & Albshri, 2020), it is far too early to speak of the mass adoption of this technology.

Blockchain in Saudi Arabia's higher education sector remains mostly an unexplored area. Saudi researchers have so far concentrated on the reviews of blockchain applications in higher education (Alam & Benaida, 2020; Alammary, Alhazmi, Almasri, & Gillani, 2019; Malibari, 2020) whereas empirical studies are virtually absent. To fill this gap and to offer practical guidance for blockchain implementation in Saudi colleges and universities, this study develops and tests a framework for blockchain adoption in the Saudi higher education sector. Specifically, the proposed model investigates the influence of organisational, technological, environmental, and human factors on blockchain adoption in the context of Saudi higher education institutions. It is expected that the study results will aid administrators and IT professionals in developing actionable, practical steps for blockchain integration in educational institutions to extract the maximum benefit.

1.3 Research Context

Saudi Arabia is the largest country on the Arabian Peninsula with a total area of 2,250,000 square kilometres and an estimated population of about 34.2 million (CIA, 2022). The contemporary education system in Saudi Arabia has its roots in the 1970s. Prior to this, the traditional *kuttab* system consisting of religious schools offered limited education opportunities for privileged families. The absence of a reliable network of educational institutions available to the masses caused extremely high illiteracy rates: 85% among men and 98% among women by the end the 1960s (Hosen, 2018). The rapid expansion of educational programs was largely driven by the growing oil revenues which allowed the country to invest in educational institutions, infrastructure, and human resources. In 1970, the first Five Year Development Plan emphasized for the first time the need for education improvements at the national level and outlined the initial steps in creating a network of education institutions across the country. Within the next fifteen years, enrolments in elementary schools increased by over 190%, in intermediate schools by 375%, and in secondary schools by over 700% (Allahmorad & Zreik, 2020).

The government's commitment to expanding education has remained strong over the past decades. Saudi Arabia has consistently invested a substantial portion of state revenue in the educational sector, even in times of falling oil revenue. Experts noted that this is prompted in part by the realization of the finite hydrocarbon revenue streams in the future and the need to diversify the economy as a result (Horschig, 2016; Moshashai, Leber, & Savage, 2020). Starting from the 1990s, spending on education remained one of the largest budgetary lines ranging from 4% to over 8% share of GDP, one of the highest among the OECD countries (Euchi, Omri, & Al-Tit, 2018). Today, Saudi Arabia ranks clearly first among the Gulf Cooperation Council (GCC) countries in terms of budgeted government education expenditures (Figure 1).

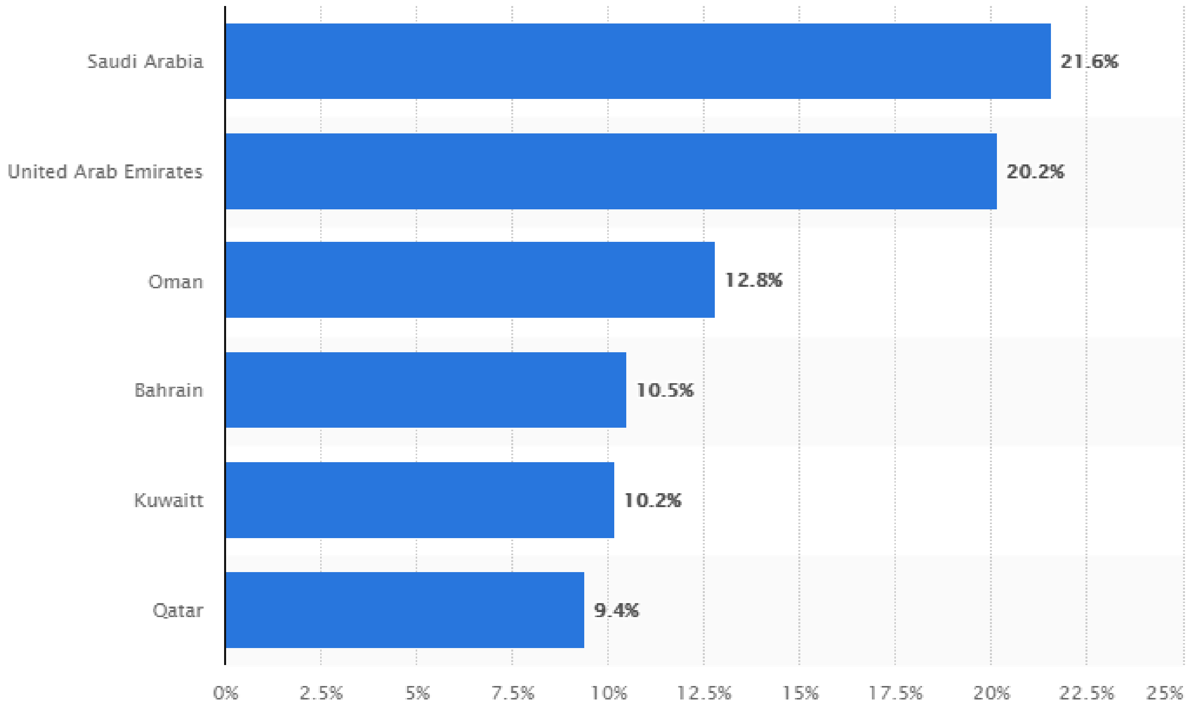


Figure 1: Comparative Expenditures on Education among the GCC Countries as a Percentage of State Budget, 2021 (Statista, 2021)

Given the importance assigned to education in Saudi Arabia as well as the amount of government expenditure on it, it is not surprising that the education system in the country remains administered in a centralized way. The Ministry of Education (MOE) is the main governing body that formulates education policies and exercises oversight. Additionally, the Ministry of Higher Education (MHE) and the Technical and Vocational Training Corporation (TVTC) are controlling government bodies in the corresponding educational areas and are accountable before the MOE. At regional, municipal and local levels, the educational policies are implemented and overseen by a large number of educational departments, directorates, and offices. Some attempts to reduce such bureaucratic load have been recently undertaken. Specifically, since 2018, about 2,000 educational institutions were granted fiscal and administrative autonomy by the MOE as well as the ability to implement school curricula changes (Allahmorad & Zreik, 2020). There are still no available data on the results of this experiment, although it generally indicates the willingness of the government to produce a more independent education system similar to those established in developed Western nations.

1.3.1 Higher Education in Saudi Arabia

Higher education has been given special attention in Saudi Arabia within the national development strategy, especially given the country's relatively short history of higher education. The first full scale higher education institution, King Saud University, was established only in 1957. However, under the educational programs guided by the first development plans, Saudi Arabia opened six more universities and increased higher education enrolments from 1969 to over 6900 in the following twenty years (Saleh M. , 1986). Still, higher education in the country remained more of a privilege than a universal opportunity up until the 2000s when the focus shifted towards making higher education accessible to wider social groups. From a comparative perspective, the higher education gross enrolment ratio in 2000 was about 22%, while in 2018 it reached a huge 68%, which is on par with France and Canada (Figure 2).

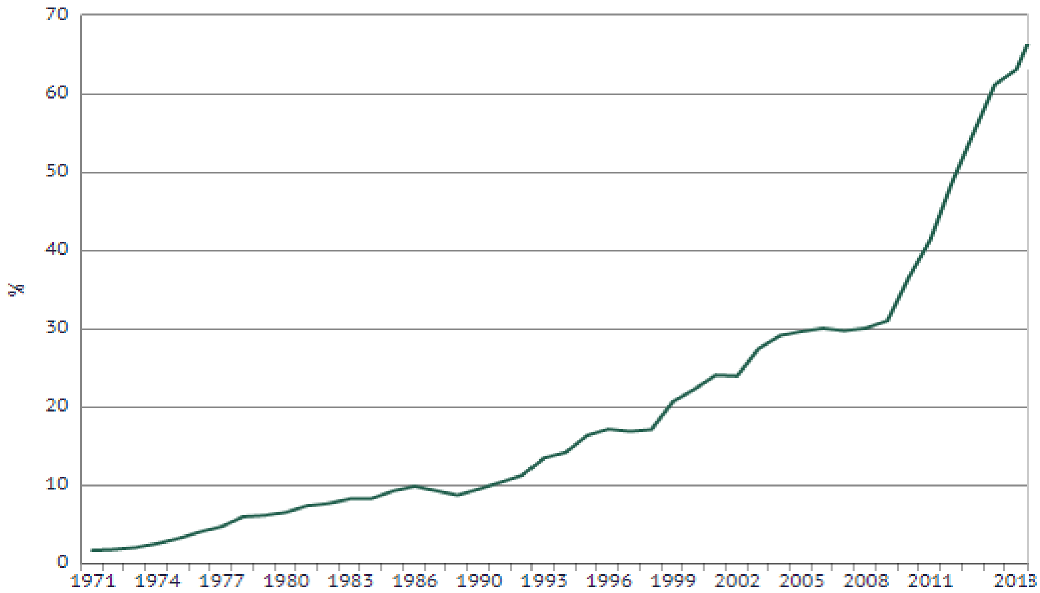


Figure 2: Saudi Arabia's Gross Enrolment Rate for Higher Education: 1971-2018 (Allahmorad & Zreik, 2020)

This growth in enrolments corresponded with the growth in higher education offerings both inside and outside of the Kingdom. On the home front, the number of public universities expanded to 29 by 2020, with additional hundreds of colleges and vocational training schools available. However, public institutions alone have been unable to satisfy the growing higher education demand. As a result, the MHE allowed the development of the private higher education sector in an attempt to offer additional educational capacity, reduce public education costs and introduce more options for higher education attainment. In the beginning of 2021, the MOE accredited 14 private universities and about 40 college programs (Saudi Ministry of Education, 2022). While the total enrolment in private higher education institutions is about 5% of the total enrolment, it is expected that they will play a growing role in the education sector development by absorbing excess capacity of the quickly growing college-age population in Saudi Arabia (Allahmorad & Zreik, 2020).

In addition to the domestic higher education offerings, Saudi Arabia has become one of the largest providers of funds in the world for national students seeking education abroad. The King Abdullah Scholarship Program launched in 2005 introduced full scholarships for Saudi undergraduate and graduate degree seekers, covering tuition and living expenses for students and their spouses in more than 30 countries. The program has produced over 200,000 graduates with foreign university diplomas since its launch (Kottasova, 2016). The recent global oil price crash prompted some cuts in the program and although it continues today, it is limited to the top 200 international schools and 50 programs (Allahmorad & Zreik, 2020).

The latest available data at the time of writing showed 1.62 million Saudi students enrolled in higher education institutions with 90% enrolled in public colleges and universities and the rest equally distributed between those studying in private schools and abroad (Allahmorad & Zreik, 2020). An important achievement of the higher education system is providing opportunities for female students, which was unthinkable a few decades ago. Figure 3 offers an outlook of the student distribution by gender across six higher education programs. It can be seen that female students are equally represented in Bachelor's, Higher Diploma [1], and Master's programs, although they still lack representation in Associate, Graduate Medical, and Doctoral programs. In 2009, the King Abdullah University of Science and Technology (KAUST) became the first co-educational university, although higher education in the country remains mostly separated by gender. Another notable change in higher education governance has been the introduction of King Saud University stakeholders into the decision-making process and policy formulation in relation to this oldest and largest university in the country. These moves demonstrate that higher education in Saudi Arabia may be both a driver for development and experimental ground for relaxing government's hold on various aspects of life in Saudi Arabia.

[1] Higher Diploma degree in Saudi Arabia is given upon completion of additional coursework after Bachelor's degree. The difference between it and a Master's degree is that such programs are usually shorter (1 year approximately) and they do not require the completion of a research project.

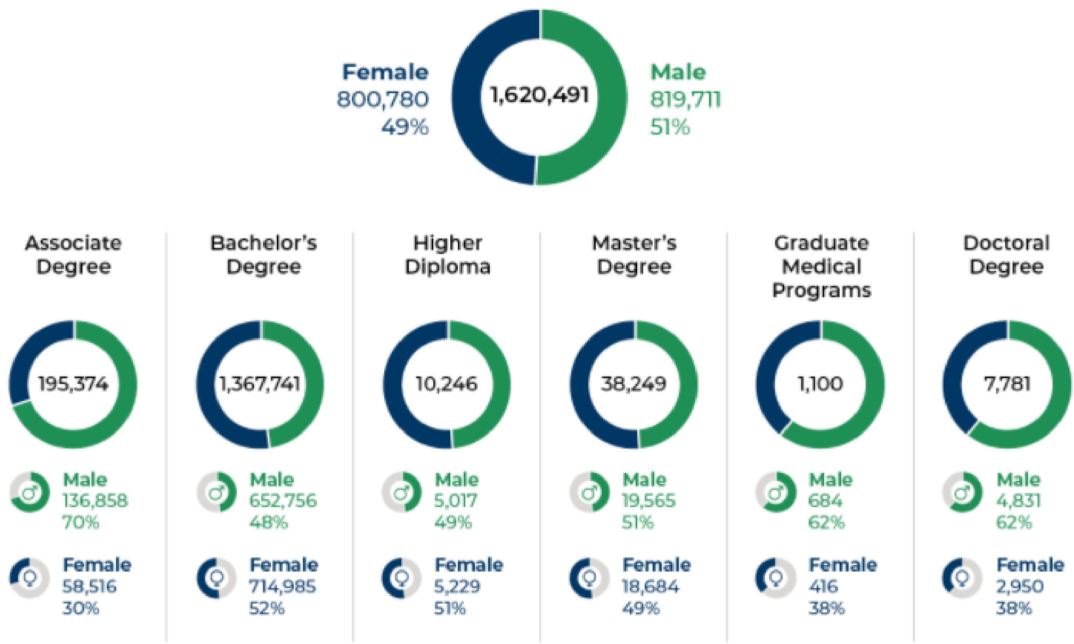


Figure 3: Distribution of Saudi Students by Number and Gender across the Higher Education Programs (Allahmorad & Zreik, 2020).

The present development initiatives in the Saudi higher education sector are driven by two factors: the national development outlook formulated within the Vision 2030 plan and the integration of education and technology. Vision 2030 is the strategic development framework for Saudi Arabia introduced in 2016. With the main emphasis on reducing the dependence on oil, the plan assigns one of the major roles in this process to education. A description of one of the three major themes of Vision 2030 includes the following:

> *"a thriving economy provides opportunities for all by building an education system aligned with market needs and creating economic opportunities for the entrepreneur, the small enterprise as well as the large corporation.* (Vision 2030, p. 13)

Section 2.1.1 of Vision 2030 also provides the specifics on how education will contribute to the country's economic growth. The major goals in this regard are:

- achieving student results in global education indicators above the international averages;
- placing five Saudi universities in the top global 200 rank by improving the quality of education;
- developing a reliable network of career counsellors;
- investing in strategic private-public partnerships;

- improving monitoring and statistics on student population dynamics and chosen majors to close the gap between education outcomes and the market needs.

Technology is seen as an important driver for many of these initiatives and the development of the higher education sector in general. Looking at the history of information and communication technology (ICT) integration in the education sector in Saudi Arabia, three phases can be identified. The first phase took place during the Fifths and Sixth Development Plans in 1990-2000. It focused on the introduction of ICT courses to the curriculum and establishing the first IT programs. The second phase took place during the 7th, 8th, and 9th Plans (2000-2014) and was characterized by large-scale training programs in ICT for both educators and students as well as the mass introduction of ICT into education processes. At present, the phase of digital transformation is taking place. It can be viewed that the phase started in 2016 with the establishment of the Tatweer Educational Technologies Company by the MOE.

Tatweer, which is essentially a technology arm of the Saudi MOE, is tasked with developing high-tech solutions and e-services for the education sector. It is working closely with both private and non-for-profit organizations to achieve the major goals of the digital transformation of the education sector (Tatweer, 2022). According to the official Tatweer strategy outlined during the Sustainable Education Meeting 2018, the process of digital transformation involves: 1) the creation of common digital platforms across education entities; 2) launching related digital initiatives; and 3) investing in digital education asset developments (TETCO, 2018). A number of core initiatives have been launched to achieve this, ranging from upgrading skills of university instructors to raising education quality and outcomes through digital technologies. However, the most ambitious and technology-driven initiative is the transfer to smart schools.

According to the Tatweer site (Tatweer, 2022), the company sees smart schools as completely transforming the traditional learning experience. This goes beyond simply introducing smart technologies for classrooms; rather, it can be seen as a new approach to learning mediated by modern technologies. Some specific aspects of smart schools are outlined as follows:

1) Interactive digital learning environment via common virtual platforms to connect anyone, anywhere;

2) Utilization of applications and platforms on the bases of those commonly used by learners for more intuitive access to educational resources;
3) Integrated learning systems for interactive distance learning;
4) Digitization of common tasks and reducing environmental impact through the elimination of excess paperwork, ink, and other unnecessary physical attributes;
5) Expanding learning services both inside and outside school boundaries.

While relatively new for Saudi Arabia, the concept of a smart university has been prominent in most developed nations which underwent the digital revolution earlier (Uskov, Bakken, Howlett, & Jain, 2018). Recently, a growing body of research emerged on the incorporation of blockchain technology for smart school initiatives with some promising applications (Alam & Benaida, 2020; Chen, Xu, Lu, & Chen, 2018; Lam & Dongol, 2020). In Saudi Arabia, blockchain has been recently deployed by the Saudi Arabia Monetary Agency (SAMA) for money transfer and deposit security purposes (Hafiz, 2020). In higher education, however, blockchain applications remain rather limited. The only notable example has been the KAUST experiments with Blockcerts – blockchain-based diplomas for its graduates (Rogers C. , 2018). The range of possible applications of blockchain is much wider, and it can substantially enhance the transfer towards digital education pursued by the Saudi MHE. The following section reviews blockchain technology, its applications in higher education and possible barriers to adoption in Saudi Arabia.

1.4 Blockchain Technology

Blockchain was first described in the ground-breaking paper by Nakamoto in 2008 as a peer-to-peer distributed ledger to register Bitcoin cryptocurrency transactions (Nakamoto, 2008). True to its name, blockchain is, in essence, a continuously expanding chain of records (blocks) linked by cryptography. A sample Bitcoin blockchain is presented in Figure 4, showing each block contains four elements:

1) an encrypted previous block's SHA-256 hash: one-way mathematical algorithm linking data;
2) a trusted timestamp securing time for block creation and/or alteration;
3) a Merkle-tree transaction data;
4) a nonce: an arbitrary string that can only be used once.

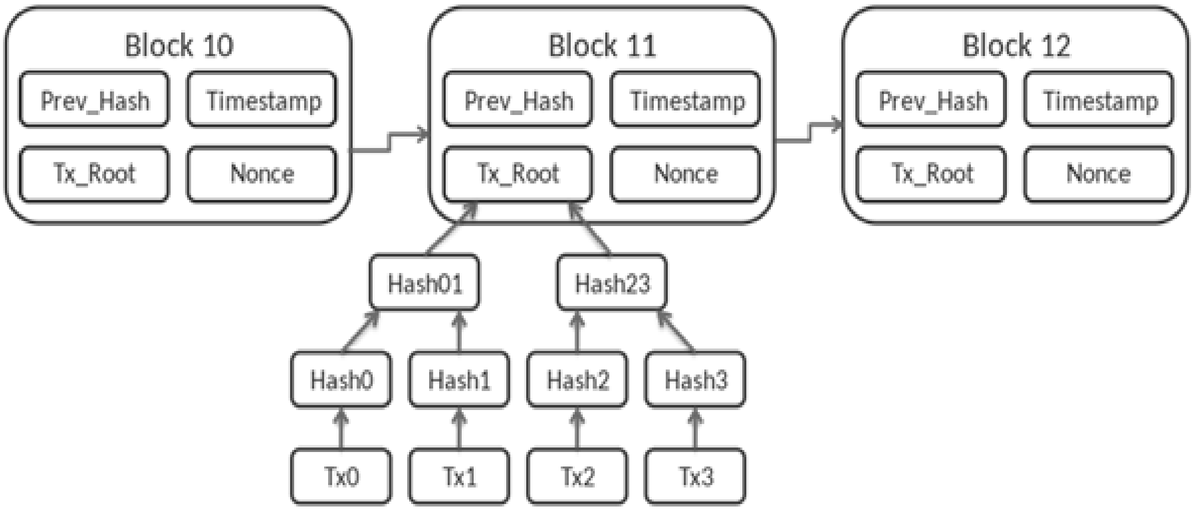


Figure 4: Illustration of Blockchain Technology Used for Bitcoins (Wander, 2013)

Blocks are created and checked by all participants in a network. Each node has a replica of the transaction ledger where it can transmit transactions to the other nodes, check the ledger against the other nodes, and insert new entries to the ledger when approved by all nodes (Nakamoto, 2008).

A sample transaction using blockchain technology is the following (as described by Chen et al., 2018). Node A initiates a transaction with Node B. A cryptographic combination of public and private keys is used by the network to uniquely identify the nodes. The transaction is sent to the network memory pool for verification and validation. When a certain number of approvals from the network nodes is achieved, it is described as reaching consensus, basically verifying and assigning validity to the transaction. This is achieved through mining – use of a consensus algorithm to achieve an updated state of the distribution ledger (Kraft, 2016). A new block is then formed on the network and updated by every node on their respective ledgers. The block receives a record of all the transactions which have taken place, a timestamp, and becomes linked to the previous block with a cryptosignature. Such a process ensures that each transaction is unique: any attempt to interfere with it or alter it would inevitably break the existing chain (Chen et al., 2018).

Blockchain technology has a number of distinct characteristics which determine its usability and potential value and applications. First, based on the review above, blockchain is a completely decentralized system. Because it relies on a distributed network to conduct and confirm transactions, no third parties are involved, and no single centralized structure is necessary to its use. All transactions can be conducted from different systems and devices connected to a network (Chen et al., 2018).

Second, blockchain ensures the absolute transparency of all transactions. They are chronologically arranged with unique timestamps. Any node on the network has access to the same general ledger. It can inspect any block and transactions that the block describes. This not only ensures openness and equal access to transaction-related information but also eliminates the need for such a property as trust. Indeed, there is no need to trust another party in a transaction when the entire history can be freely examined and confirmed with no possibility for anyone to singlehandedly alter the existing records (Abeyratne & Monfared, 2016).

Third, blockchain ensures the immutability of transactions. As previously discussed, the features which are unique to each transaction described by encrypted hash links, timestamps, and nonces make it impossible to tamper with transactions. One way to tamper with blockchain would be to achieve a simultaneous change to the distributed ledger across the majority nodes on the network, which is essentially impossible due to complexity and virtually unattainable required technological power (Chen et al., 2018).

Finally, blockchain can be thought of in terms of cryptocurrency. Every network utilizing blockchain involves direct node-to-node transactions with a fixed circulation property which is defined by a strict mathematical algorithm (Chen et al., 2018). In such a system, no transactions are lost, and no system collapse of inflation will take place. This makes the system stable, pre-defined, and capped based on the originally given properties. For example, the original blockchain algorithms capped the amount of Bitcoins at 21 million (Nakamoto, 2008).

While the original use of blockchain was envisioned as a cryptocurrency driver, the properties described above make it a potentially desired technology for other applications. These were presented in a major work by Buterin (2014) which introduced a novel concept of Etherium blockchain with an embedded open source programming language. Etherium granted the possibility for everyone to write smart contracts and also opened doors for various applications of blockchain. Today, researchers indicate the current state of blockchain technology development as Blockchain 3.0 (Gatteschi, Lamberti, Demartini, Pranteda, & Santamaria, 2018). It is characterised by novel applications of blockchain in non-financial sectors. Higher education is one such field.

1.5 Research Significance and Contribution

This research operates on the intersection of the technology adoption and education improvement studies in the Saudi Arabia context. Considering the increased student mobility and globalised nature of higher education, colleges and universities in Saudi Arabia are faced with growing competitive pressures. Innovative technologies in education have long ago been recognised as an important factor in gaining competitive advantage (Cheng, Cham, Dent, & Lee, 2019; Mainardes, Ferreira, & Tontini, 2011; Waller, Lemoine, Mense, & Richardson, 2019). This motivates higher education institutions to constantly look for new opportunities by adopting novel technologies such as blockchain.

Despite the relative newness of blockchain, it has already found practical applications in a number of industries, such as banking and finance (Kulkarni & Patil, 2020; Rajnak & Puschmann, 2020), supply chain management (Alazab, Alhyari, Awajan, & Abdallah, 2021; Aslam, Saleem, Khan, & Kim, 2021; Choi, Chung, Seyha, & Young, 2020), energy (Andoni, et al., 2019; Wang & Su, 2020), the public sector (Reddick, Cid, & Ganapati, 2019; Warkentin & Orgeron, 2020), healthcare (Hasselgren, Kralevska, Glikoroski, Pedersen, & Faxvvag, 2020; Pirtle & Ehrenfeld, 2018), and tourism (Rashideh, 2020; Valeri & Baggio, 2021) among others. The potential of blockchain in education is closely related to the continuing digitization of educational services, which requires an increased level of security, speed and reliability of information exchange, enhanced data management, and prevention of fraud. Many of these and other pertinent issues in education and related services can be potentially addressed by the unique features of blockchain technology such as decentralization, transparency, immutability, and security of transactions (Alammary, Alhazmi, Almasri, & Gillani, 2019; Raimundo & Rosario, 2021). This explains the great amount of interest in blockchain for education from both academics and technology practitioners. However, researchers have noted that literature in this field remain fragmented, focusing primarily on existing and potential blockchain applications as well as opportunities and challenges for these applications in education institutions (Alammary, Alhazmi, Almasri, & Gillani, 2019; Ullah, Al-Rahmi, Alzahrani, Alfarraj, & Alblehai, 2020).

The limited and incomplete body of research on blockchain adoption in education in general and in Saudi Arabia universities in particular serves as the primary motivator for this study. The expected contribution of this research is both theoretical and practical as outlined below.

1.5.1 Theoretical Contributions

a. This study extends the technology adoption theory by identifying factors influencing blockchain computing adoption in the Saudi education sector. It expands on the well-known theories of adoption by integrating several well-known theoretical constructs into a more holistic framework.

b. The study presents a refined theory of blockchain adoption in the higher education sector and tests it within a specific context where it has not been tested before. As such, the role of both theoretically established and newly discovered contextual factors is explored.

c. The study tests the applicability of the well-known adoption and established theories in the Saudi context.

1.5.2 Practical Contributions

a. The study produces an actionable framework of blockchain adoption which demonstrates what factors influence and impede blockchain adoption in higher education institutions in Saudi Arabia.

b. The study offers a roadmap for Saudi colleges' and universities' decision makers in implementing blockchain-related initiatives within their respective institutions.

c. The study offers a validated instrument (questionnaire) to study adoption either through a combination of the considered factors or test the effect of each dimension more thoroughly.

d. To the best knowledge of the author, this is the first study of its kind to empirically explore the combinatory effect of technological, organisational, environmental and quality factors and barriers to blockchain adoption in Saudi HEIs. It can serve as a foundation for developing a tool to guide HEI organisations and, perhaps, the industry as a whole on whether, when and how the adoption process should proceed.

1.6 Thesis Outline

This thesis consists of nine chapters, described as follows:

Chapter 1 provides a general research background, including the study context and the blockchain technology basics. It also explains the current research's significance and contribution.

Chapter 2 provides a systematic literature review of blockchain adoption in education. Three major areas are covered: evidence of blockchain adoption in higher education, reasons for blockchain adoption in higher education and relevant factors in the adoption process. A rigorous methodology for the search and inclusion of studies in the review is discussed, and the analysis of themes for blockchain and potential uses in higher education is presented. The findings are used to identify the gaps in the existing knowledge to place this research within the body of knowledge on blockchain adoption in higher education.

Chapter 3 presents the problem definition, outlines the research questions and objectives.

Chapter 4 provides an overview of the solution to the formulated problem, which is split into research subquestions. This chapter also reviews the study methodology and describes the major research phases.

Chapter 5 presents the research model to study blockchain adoption in Saudi HEIs. Each model dimension is discussed separately and the relationships between the major factors are presented and justified. Accordingly, the key hypotheses to investigate within the framework are presented.

Chapter 6 offers a detailed review of the Phase I results of the research. Phase I is represented by a qualitative data collection and analysis. Accordingly, the chapter provides an overview of the research sample and the results of the interviews. Based on these results, the original model presented in Chapter 4 is refined to become the foundation for the wider quantitative research.

Chapter 7 offers a detailed review of the Phase II results of the research. These are the results of a large-scale survey. The chapter first offers a descriptive analysis of the study sample. Next, preliminary analyses of the data are reported, including tests for data normality, validity, reliability, and multicollinearity. Adjustments to the model are made and justified where necessary. Finally, the results of the hypotheses tests are presented.

Chapter 8 offers a comprehensive review and discussion of the study findings. It begins with a review of the study model evolution and a comparison of the results from Phase I and Phase II of the research. Next, thorough discussions and explanations of the results are provided for every hypothesised relationship in the study model.

Chapter 9 draws the main conclusions arising from the study. It places the study findings within the existing body of research on blockchain adoption in education and draws theoretical and practical implications of the research. Finally, general limitations of the study are acknowledged and directions for future research are outlined.

Figure 5 visualises the study plan and shows how the chapters are connected to each other.

1.7 Conclusion

This chapter provided an overview of the work undertaken within the current thesis. Given the importance of technological developments in the education sector, the study looks into the process of blockchain adoption in the context of Saudi colleges and universities. The purpose is to develop and test a practical framework which could be used by the administrators to guide the adoption process in an effective way. The study contribution, therefore, is both theoretical and practical. On the one hand, it proposes a new framework on the basis of the existing adoption theories, supplements it with the contextual factors and empirically tests the proposed relationships. On the other hand, the resulting framework is an actionable tool which can be applied in practice to stimulate blockchain adoption in higher education establishments.

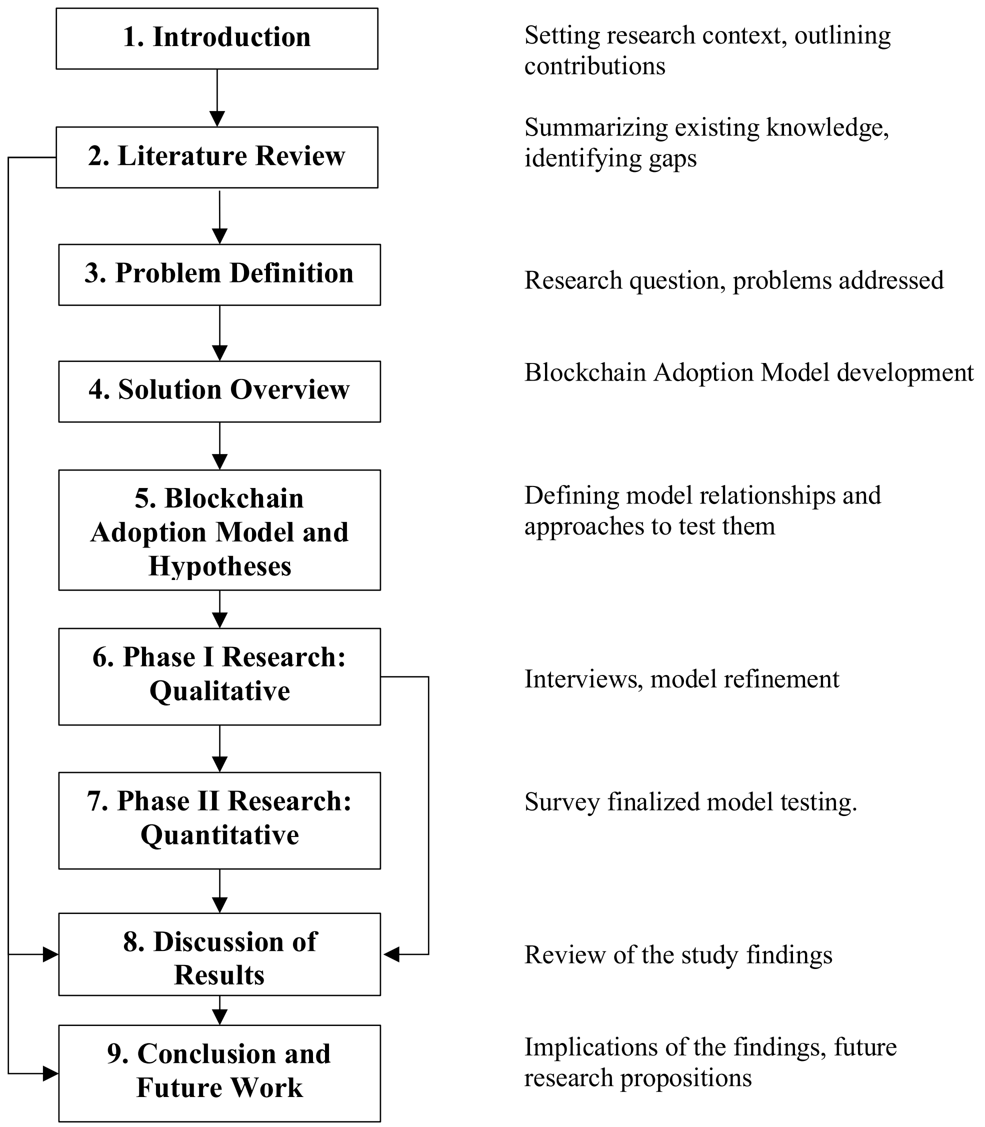


Figure 5: Thesis Structure

2 A Systematic Literature Review of Blockchain Adoption in Education

2.1 Introduction

The purpose of this chapter is to review the relevant literature pertaining to the research topic. Three major areas are covered: evidence of blockchain adoption in higher education, reasons for blockchain adoption in higher education and relevant factors in the adoption process. A rigorous methodology for the search and inclusion of the studies in the review is discussed, and the analysis of themes for blockchain and its potential uses in higher education is presented. The findings are used to identify the gaps in the existing knowledge to place this research within the body of knowledge on blockchain adoption in higher education.

Section 2.2 defines the method used for extracting and analysing the literature. Section 2.3 summarises the extracted literature by year and publication type. Section 2.4 reviews the existing evidence of blockchain adoption in the educational sector. Section 2.5 summarises the key reasons for higher education institutions (HEIs) to adopt blockchain. Sections 2.6 and 2.7 review the adoption barriers and factors respectively as identified in the existing literature. Section 2.8 reviews the theoretical frameworks for blockchain adoption in HEIs. Section 2.9 discusses the key limitations of the conducted literature review. Finally, Section 2.10 outlines the major research gaps arising from the literature review.

Sections of this chapter have earlier been published in the following journal article:

Alalyan, M.S., Jaafari, N.A., Hussain, F.K. & Gill, A.O. (2023). A systematic review of blockchain adoption in education institutions. *International Journal of Web and Grid Services,*19(2), 156-184.

2.2 Literature Research Method

This study followed a systematic literature review (SLR) approach. An SLR is generally defined as “a literature review that is designed to locate, appraise, and synthesise the best available evidence relating to a specific research question in order to provide informative and evidence-based answers” (Boland, Cherry, & Dickson, 2017, p. 2). It is recognised as more encompassing and rigorous in comparison to the traditional approach to a literature review based on narratives (Booth, Papaioannou, & Sutton, 2012; Okoli, 2015).

The benefits of SLR have been widely recognised in the fields of both education and emergent technologies (Hiebl, 2021; Zawacki-Richter, Kerres, Bedenlier, Bond, & Buntins, 2020). This study follows an SLR approach, as proposed by Okoli (2015) and Kitchenham & Charters (2007), because they were developed primarily for reviews in the information technology field. The SLR process is demonstrated in Figure 6 with a description of each stage.

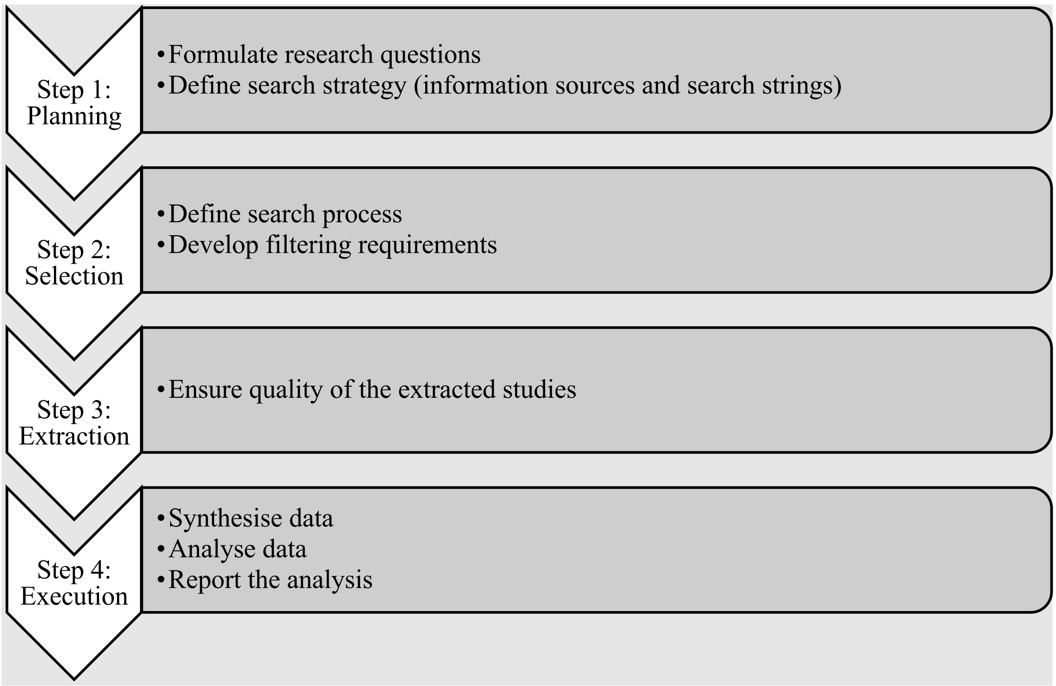


Figure 6: SLR Process (adapted from Kitchenham & Charters, 2007; Okoli, 2015)

2.2.1 Step 1: planning

This study focuses on the adoption of blockchain in education. Given the identified gaps in the existing knowledge, the study aims to single out the influential factors in this process as well as look into commonly used theoretical foundations for blockchain adoption research in the educational sector. Table 1 outlines the research questions formulated for the SLR and the rationale behind them.

Table 1: SLR Questions

Research Question	**Rationale**
RQ1: what kind of evidence exists of blockchain adoption in education?	To identify the areas where blockchain has been found useful for education institutions and offer a research type taxonomy.
RQ2: what are the main reasons for education institutions to adopt blockchain?	To analyse the motivation behind blockchain adoption by education institutions.
RQ3: what factors influence blockchain adoption	To determine and classify the factors that aid in

by education institutions?	blockchain adoption by education institutions.
RQ4: what are the barriers to blockchain adoption by education institutions?	To determine and classify the factors that impede blockchain adoption by education institutions.
RQ5: what theoretical frameworks have been used to study blockchain adoption by education institutions?	To identify the models that can be useful for future empiric investigations of blockchain adoption.

The literature search was conducted across eight scientific databases:

- *ACM*
- *IEEE*
- *ProQuest*
- *EBSCO IT*
- *ScienceDirect*
- *SpringerLink*
- *Taylor & Francis*
- *Web of Science*

Additionally, two education research databases were searched:

- *ERIC*
- *Education Research Complete*.

The databases were selected for their reputation, high index impact, and specialization in technology and education topics. Additionally, a search by Google Scholar was conducted at the end to account for publications potentially missed during the original search. The time frame was set between 2008 (first paper published on blockchain by Nakamoto) and May 2021. Following Okoli (2015) and Kitchenham & Charters (2007), the search strings were developed based on the research questions' themes, alternative spellings of the key terms, and using the Boolean operators. The following query strings were used:

[“Blockchain” OR “Block chain” OR “Distributed Ledger”] AND *[“Application” OR “Use” OR “Usage”]* AND *[“Education” OR “Learning” OR “Teaching”]*

[“Blockchain” OR “Block chain” OR “Distributed Ledger”] AND *[“Adoption” OR “Use” OR “Usage”]* AND *[“Education” OR “Learning” OR “Teaching”]*

2.2.2 Step 2: selection

After the search, duplicate titles and papers were eliminated from the review with the most recent version retained. Next, the titles and abstracts of the retained papers were screened for the initial inclusion of articles in the review. The following exclusion criteria were applied:

1. the paper is not in English;
2. the paper is incomplete or missing full text (in press articles were still included);
3. the paper does not cover blockchain adoption and/or use by education institutions;
4. the paper represents an opinion without solid methodology or research.

2.2.3 Step 3: quality assurance

The full textы of the remaining articles were screened to ensure that they were relevant to the research questions and represented high quality research (quality assurance). The papers were retained for analysis based on a quality score derived from four quality assurance questions listed in Table 2. The answers received the following grading: 1 point for "Yes," 0.5 point for "Partially," and 0 for "No." The acceptable score for inclusion in the analysis was 2.5 and higher.

Table 2: Quality Assurance Questions

Quality Assurance Questions	Grading Criteria
1. Do the authors state the study purpose? 2. Is the methodology clearly described? 3. Is the level of rigor for study execution and analysis appropriate? 4. Are the findings useful for academic research and/or practical use?	Yes = 1 Partially = 0.5 No = 0

2.2.4 Step 4: execution

The final step in the review involved data synthesis and reporting the results. The data about and from the extracted papers were summarised and grouped into themes corresponding to the research questions. The final results are presented in the form of tables and figures for ease of analysis and interpretation.

2.3 Summary of the Extracted Literature

The initial searches over the databases returned 335 studies in total: 124 from Scopus, 65 from IEEE, 62 from ProQuest, 59 from EBSCO Education Complete, 15 from ACM, and 10 from EBSCO IT. The initial screening for duplicates eliminated 94 papers. Another 77 papers were eliminated after the abstract analysis. Finally, an in-depth analysis of the remaining papers and applications of the quality assurance criteria left 107 studies for the final review (Figure 7).

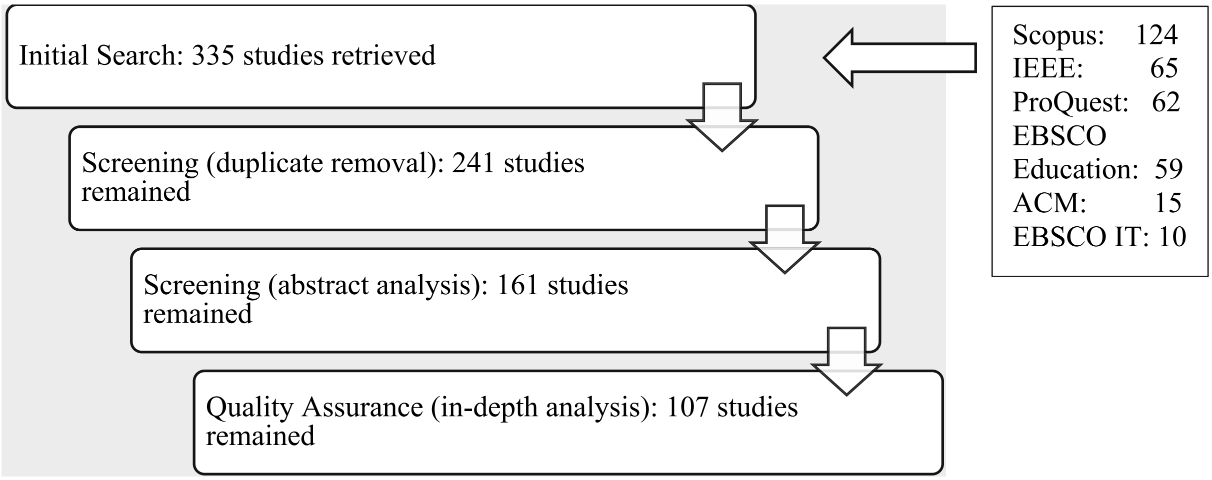


Figure 7: Filtering Process

Table 3 presents the distribution of the studies by publication type. The majority of papers in the review are conference papers and journal articles with an almost equal number of publications (48 and 46 papers respectively). Book chapters and workshop papers accounted for 5 publications each. Three more papers were represented by a report, a colloquium paper, and a symposium paper.

Table 3: Distribution of Extracted Papers by Publication Type

Publication Type	**Number of Papers**
Conference Paper	48
Journal Article	46
Book Chapter	5
Workshop Paper	5
Other (report, colloquium, symposium)	3
Total	107

2.4 Evidence of Blockchain Adoption in Education

To understand how research on blockchain adoption in education progressed, and to have a clear picture of the type of evidence in this regard, a detailed mapping of the study types was performed. This enabled the development of a taxonomy of the reviewed literature. In research, a taxonomy is generally understood as a structured and organised presentation of information and knowledge (Yazdani, Shirvani, & Heidarpoor, 2021). A number of approaches to taxonomy development for reviewed literature exist (e.g., (Creswell, 2015; Della Porta & Keating, 2008; Gall, Gall, & WR, 2007)). While different in terms of the classification of studies, they share similar methods of organising knowledge based on either research methodology or purpose of research. This study followed this pattern. The taxonomy of the reviewed research is presented in Figure 8. Three general research types were identified: 1) reviews of the existing literature and cases of blockchain use in education; 2) conceptual models and proposals for blockchain solutions and applications; and 3) empirical studies of factors influencing blockchain adoption in education. Within each of these types, research subcategories were distinguished based on the study foci, research questions, and purpose. Detailed analyses for each research type dimension are presented in Figure 8.

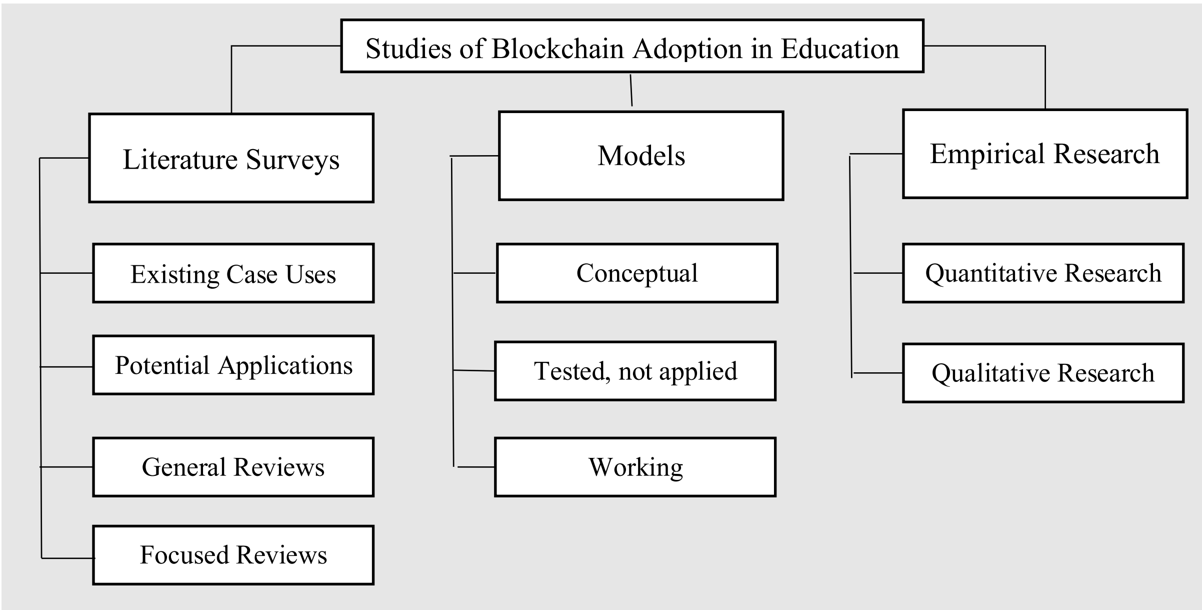


Figure 8: Blockchain Adoption in Education: Research Taxonomy

2.4.1 Literature Surveys

In total, 32 papers were identified as literature surveys, which represents 29.9% of all studies. Several types of reviews were identified, which is indicated in Table 4. Each is discussed in Table 4.

Table 4: Subcategories of Reviews of Blockchain Adoption in Education

Subcategory	Number	Studies
Reviews of Use Cases	7	(Bhaskar, Tiwari, & Joshi, 2020), (Jirgensons & Kapenieks, 2018), (Sharma & Batth, 2020), (Capece, Ghiron, & Pasquale, 2020), (Fedorova & Skobleva, 2020), (Guustaaf, Rahardja, Aini, Maharani, & Santoso, 2021), (Hameed, et al., 2019), (Kamisalic, Turkanovic, Mrdovic, & Hericko, 2020)
Reviews of Potential Applications	5	(AlHarthy, AlShuhaimi, & AlIsmaili, 2019), (Chen, Xu, Lu, & Chen, 2018), (Lindenmoyer & Fischer, 2019), (Haugsbakken & Langseth, 2019), (Kant & Anjali, 2020)
General Surveys	9	(Bhaskar, Tiwari, & Joshi, 2020), (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Raimundo & Rosario, 2021), (Awaji, Solaiman, & Albshri, 2020), (Loukil, Abed, & Boukadi, 2021), (Machado, Sousa, & Rocha, 2020), (Yue, Xiaofeng, & Huagang, 2020), (Gresch & Camilleri, 2017), (Yumna, Khan, Ikram, & Ilyas, 2019)
Focused Surveys	11	(Ma & Fang, 2020), (Novotny, et al., 2018), (Williams, 2019), (Arndt & Guercio, 2020), (Caldarelli & Ellul, 2021), (Castro & Au-Yong-Oliveira, 2021), (Fernandes-Carames & Fraga-Lamas, 2019), (Liu & Zhu, 2021), (Mikroyannidis, Domingue, Bachler, & Quick, 2018), (Pfeiffer, Bezzina, Wernbacher, & Kriglstein, 2020), (Sahonero-Alvarez, 2018)

Reviews of use cases are papers which discuss real-life applications of blockchain in education. In total, 7 such papers were identified. Four studies described use cases by educational institutions: colleges and universities. Capece et al. (2020) reviewed uses cases of Blockcerts developed by Massachusetts Institute of Technology (MIT). Jirgensons and Kapieniks (2018) reviewed blockchain applications by five universities in USA and Europe. More comprehensive reviews by Kamisalic et al. (2020) and Fedorova and Skobleva (2020) respectively identified use cases in 20 and 23 colleges and universities globally. The total number of blockchain adopting education institutions described in these studies is 29. The majority of the institutions adopted blockchain for issuing, storing, and verifying diplomas. Six institutions used blockchain for student identity verification and preventing fraud. Five institutions integrated payments in cryptocurrencies. Five colleges and universities used blockchain solutions to create novel forms of online education interactions between students and instructors. Three institutions, all Chinese, used blockchain for intellectual property protection. Two universities integrated blockchain for administrative tasks such as the management of digital microcredentials. One university experimented with a blockchain-based accreditation system, and one university introduced a blockchain-based peer review academic publishing platform. Table 5 offers a summary of the use cases discussed in literature.

Table 5: Blockchain Adoption by Colleges and Universities

Application Field	N	Education Institutions
Issuing, storing, and verifying diplomas	22	Aristotle Athens University of Economics and Business, Central New Mexico Community College, Democritus University of Thrace, Holberton School of Software Engineering, Malta College of Arts Science and Technology, MIT, Ngee Ann Polytechnic, Penza State University, Southern New Hampshire University, Synergy University, The Open University, University of Bahrain, University of California, University of Maribor, University of Melbourne, University of New Hampshire, University of Nicosia, University of Rome, University of Southampton, University of Texas at Austin, University of Thessaloniki, Woolf University
Student identity management and solutions	6	Aristotle Athens University of Economics and Business, Democritus University of Thrace, Holberton School of Software Engineering, MIT, University of Thessaloniki, Woolf University
Cryptopayments	5	King's College, Simon Fraser University, University of Cumbria, University of Nicosia, Woolf University
Novel teacher/learner platforms	5	Synergy University, University of Southampton, The Open University, University of Texas at Austin, Woolf University
Intellectual property protection	3	Chinese Academy of Sciences, Shenzhen University, Zhejiang University
Administrative tasks	2	University of Maribor, Woolf University
Institution accreditation	1	The Open University
Peer review open publishing platform	1	University of Pittsburgh

It should be noted, however, that the actual number of educational institutions that either adopted or experimented with the adoption of blockchain is likely much higher. For example, Fedorova and Skobleva (2020) reported that up to 20% of Canadian colleges and universities could be using blockchain technology for education achievement certificates and diplomas. Therefore, there is a growing need to continuously and consistently report on blockchain adoption in higher education to have a clearer picture of its current state and perspectives in the industry.

Another three papers focused on blockchain-based education platforms. Sharma and Bhutt (2020) described five such platforms. Hameed et al. (2019) discussed nine. Finally, Guustaaf et al. (2021) reviewed twelve ready-to-use blockchain platforms for the educational sector. However, these papers were mostly descriptive. While offering useful and comparative reviews of the blockchain-for-education projects, they did not discuss their uses by educational institutions. As such, there is no academic evidence of the adoption of such systems or the success of these initiatives.

A separate category of reviews considered potential applications of blockchain for education. These were the papers where researchers reviewed the areas in education where blockchain could offer benefits for both institutions and students. In total, 6 such papers were identified, which are summarised in Table 6. Overall, the range of potential applications for blockchain is rather wide, which presents many areas for future research and case studies on novel approaches to blockchain use in education.

Table 6: Papers on Potential Blockchain Uses in Education

Paper	Potential Application Fields Reviewed
Chen et al. (2018)	Achievements and certificates, assessment platforms, online learning, digital badges, smart contracts
Al Harthy et al. (2019)	Digital badges, direct transactions, secured records, library administration, instructor achievements, publishing
Lindenmoyer & Fischer (2019)	Timeless achievement data, prevention of academic fraud, secure and trusted resumes, admissions, academic advancement tracking
Haugsbakken et al. (2019)	Transcripts management, competence badges, learner digital identity, flexible degree design, secure intellectual property
Kant & Anjali (2020)	Administrative tasks, learning delivery, record keeping, accreditation, transfers, digital badges, smart contracts
Nurhaeni et al. (2018)	Academic certificate management, open badges

The third type of literature survey papers are general reviews. These cover a broad range of topics on blockchain without focusing on particular blockchain applications or areas. In total, 9 papers were identified. The unifying purpose of such reviews is usually to offer a comprehensive view on the state of research. It involved an examination of the blockchain applications in education, developing a list of challenges and benefits of blockchain for education and identifying the research gaps. At the same time, some topics were omitted in these reviews. No paper attempted to systematise the existing research by type and develop a taxonomy of knowledge. Further, only one paper reviewed the potential factors driving the adoption of blockchain by education institutions. These are the clear gaps that this research aims to fill. Table 7 summarises general review studies and the topics they covered on a comparative basis with this research.

Table 7: General Reviews of Blockchain Adoption in Education

Study	SLR?	Applications Reviewed	Reasons to Adopt Reviewed	Barriers to Adopt Reviewed	Factors Driving Adoption Reviewed	Taxonomy Developed
Gresch & Camilieri (2017)		x		x		
Alammary et al. (2019)	x	x	X	x		
Yumna et al. (2019)	x	x	X	x		
Awaji et al. (2020)	x	x		x		
Bhaskar et al. (2020)	x	x	X	x		
Machado et al. (2020)	x	x	X	x		
Yue et al. (2020)		x	X	x	x	
Loukil et al. (2021)	x	x	X	x		
Raimundo & Rosario (2021)	x	x	X	x		
This Research	x	x	X	x	x	x

Focused reviews represent the largest proportion of literature surveys with 11 papers in total. These papers explored the state of blockchain adoption in a particular field or area of education. The number of focused surveys increased rapidly since 2018 which coincides with the reports of successful implementations of blockchain in a number of universities and possibly with the need to look into new areas of blockchain applications. The majority of the reviews focused on blockchain applications for student records and proof of education. Arndt and Guercio (2020) and Caldarelli and Ellul (2021) reviewed blockchain applications for transcript management. Castro and Au-Yong-Oliveira (2021) reviewed blockchain applications for issuing and verifying diplomas. A review by Ma and Fang (2020) focused on blockchain applications for record keeping, decentralised education, and certificates. Pfeiffer et al. (2020) reviewed blockchain applications for student data management and the prevention of identity fraud. Three reviews focused on blockchain applications for the creation of new, student-centric online learning environments. Mikroyannidis et al. (2018) reviewed literature related to blockchain for eportfolios, accreditation, and tutoring. Williams (2019) considered blockchain applications for decentralised, individualised learning curricula. Fernández-Caramés (2019) reviewed blockchain applications for the creation of a smart university. Two studies offered focused reviews on blockchain applications for specific learning programs such as engineering education (Sahonero-Alvarez, 2018) and cultural, creative design (Liu & Zhu, 2021). Finally, Novotny et al. (2018) reviewed blockchain literature related to blockchain applications in academic publishing.

One clear limitation of these focused reviews, however, is the absence of rigorous literature review methodologies. In fact, only Caldarelli & Ellul (2021) and Castro & Au-

Yong-Oliveira (2021) used systematic literature review approaches that would enable their research to be replicated and expanded. It is also clear that the number of potential education fields for blockchain applications represented in these studies is rather limited in comparison to the range of applications described in the general review studies and discussed above.

2.4.2 Models

The second largest category of studies of blockchain adoption in education is represented by model studies with a total of 69 papers or 64.5% of the total number. Three types of papers in this category can be identified: conceptual models, tested models, and working models.

Conceptual models are the largest subcategory with 41 papers reviewed. These studies are proposals for blockchain integration into various aspects of education process. The authors would normally present a model/architecture, discuss its benefits and the solutions they could provide in specific areas. The majority of conceptual proposals were in the areas of certification and degrees and administrative processes. Fewer, but still a substantial number of researchers proposed models for enhancing the learning process and outcome assessments. Models for intellectual property protection and smart universities were described by one paper each. The blockchain application categories discussed in the conceptual papers are presented in Table 8.

Table 8: Conceptual Models for Blockchain Implementation in Education

Application Category	Topics Covered	Papers	N	%
Administration	Admissions, Authentication, Record verification, Learning process administration, Smart contracts, Cryptopayments, Credit transfers, Data management, Identity management, Cybersecurity	(Alam & Benaida, 2020), (Ali & Sharaf, 2021), (Funk, Riddell, Felix, & Cabrera, 2018), (Han, et al., 2018), (Holotescu, 2018), (Juricic, Radosevic, & Fuzul, 2019), (Kutty & Javed, 2021), (Lee & Park, 2021), (Liu, et al., 2021), (Priya, Ponnavaikko, & Aantonny, 2020), (Rashid, et al., 2020), (Srivastaya, et al., 2018), (Zhao, Di, & He, 2020)	17	41.5%
School Certificates	Blockcerts, Immutable diploma, Certificate verification, Certificate security; Instant confirmation, Fraud prevention	(Abreu, Coutinho, & Bezerra, 2020), (Alshahrani, Beloff, & White, 2020), (Bandara, Ioras, & Arraiza, 2018), (Cheng, Lu, Xiang, & Song, 2020), (Dongre, Tikam, Gharat, & Patil, 2020),	9	22.0%

		(Eaganathan, Indrian, & Nathan, 2019), (Ghaffar & Hussain, 2019), (Gresch, Rodrigues, Scheid, Kanhere, & Stiller, 2018), (Saleh, Ghazali, & Rana, 2020)		
Enhanced Learning Environments	Learning collaboration, Ubiquitous learning, Lifelong learning, Cooperative systems, Decentralised education, Shared material	(Mikroyannidis, Domingue, Bachler, & Quick, 2018), (Liu, et al., 2018), (Lizcano, Lara, White, & Aljawarneh, 2020), (Matzutt, Pennekamp, & Wehrle, 2020), (Mikroyannidis, Third, & Domingue, A case study on the decentralization of lifelong learning using blockchain technology, 2020), (Shariar, Imran, Paul, & Rahman, 2020), (Sychov & Chirtsov, 2018), (Zhong, Xie, Zou, & Chui, 2018)	8	19.5%
Learning and Assessments	Learning credentials, Student assessment and evaluation, Learning outcomes; Competency assessment, Quizzes, Exams, Badges	(Arenas & Fernandez, 2018), (Deenmahomed, Didier, & Sunghkur, 2021), (Miah, Onalo, & Pfluegel, 2021), (Panachev, Shcherbitsky, & Medvedev, 2021), (Shen & Xiao, 2018)	5	12.2%
Intellectual Property Protection	Digital rights management, Secure academic publications, Paper verifications	(Guo, Li, Zhang, Sun, & Bie, 2020)	1	2.4%
Smart University	Blockchain-enabled platforms, Context-aware applications, Integration with IoT, Fog, Edge	(Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020)	1	2.4%
			41	**100.0%**

The second subcategory of model papers is tested models. These are conceptual models which were tested by the authors, either experimentally or in a real education environment, although these models were not implemented on a constant basis. In total, 20 such papers were identified (Table 9). The distribution of the papers follows the same pattern as the conceptual models with the majority of applications tested for certificate management and administrative tasks. Fewer researchers tested student-focused blockchain applications for learning purposes.

Table 9: Tested Models for Blockchain Implementation in Education

Application Category	Topics Covered	Papers	N	%
School Certificates	Certificate issue and verification, Diploma issue and verification,	(Budhiraja & Rani, 2019), (Gräther, et al., 2018), (Liu, Xiao, Tang, & Hosam, 2020), (Palma, Vigil, Pereira, & Martina, 2019),	6	30.0%

		(Vidal, Gouveia, & Soares, 2019), (Xu, et al., 2017)		
Administration	Transcript management, Admissions, Education records, Grade storage, Data security, Cryptopayments, Authentication, Smart contracts	(Arndt & Guercio, 2020), (Hori & Ohashi, Adaptive Identity authentication of blockchain system-the collaborative cloud educational system, 2018), (Ismail, Hameed, AlShamsi, AlHammady, & Aldhandhani, 2019), (Kanan, Obaidat, & Al-Lahham, 2018), (Mori & Miwa, 2019), (Rooksby & Dimitrov, 2019)	6	30.0%
Enhanced Learning Environments	Systems for learning evaluation and rewards, Curriculum design and personalization, Student accreditation,	(Bdiwi, de Runz, Cherif, & Faiz, 2019), (Kontzinos, et al., 2019), (Lam & Dongol, 2020), (Sharples & Domingue, 2016)	4	15.0%
Learning and Assessments	Lifelong learning, learning trace repositories, Exam paper distribution and audit	(Cahyadi, Faturahman, Haryani, Dolan, & Millah, 2021), (Farah, Vozniuk, Rodriguez-Triana, & Gillet, 2018), (Mitchell, Hara, & Sheriff, 2019), (Ocheja, Flanagan, Ueda, & Ogata, 2019)	4	15.0%
			20	**100.0%**

The final subcategory includes working models: those which have been successfully implemented at educational institutions on a constant basis. In total, 7 case study papers were identified. The earliest study was published by Bore et al. (2017) and described the design, implementation, and evaluation of a blockchain-enabled school information hub in Kenya. Hori et al. (2018) described the CHiLO project – a decentralised learning system using virtual currency. The authors discussed the successful implementation of the first project phase for the creation and publication of e-books. Curmi and Iguanez (2018) presented action research on a prototype blockchain-based model for academic certificate issue and verification. Turkanovic et al. (2018) described EduCTX – a blockchain-based credit platform which has been implemented in two Slovenian universities. Vidal et al. (2019) described a system for blockchain-based diplomas at University Fernando Pessoa, Portugal, although they admitted that the system was feasible only if a larger number of blockchain-based diplomas are issued due to economies of scale. Mahankali and Chaudhary (2020) described the successful application of AuxCert – a blockchain-based certificate management platform for a university in India. Finally, Dudhat et al. (2021) described the Edublocs project at the University of Barcelona used to oversee and record students' academic activities.

2.4.3 Empirical Research on Adoption Factors/Barriers

The final category of studies on blockchain for education consists of empirical investigations into the factors that enable and/or impede blockchain adoption. This is by far the smallest category of studies with only 5 papers identified (Table 10). Of these, 4 papers had qualitative research designs based on interviews and focus groups. Only one paper (Ullah, Al-Rahmi, Alzahrani, Alfarraj, & Alblehai, 2020) implemented a quantitative study based on a survey. Three of these papers explored the factors that could stimulate blockchain adoption by education institutions, while two focused exclusively on barriers to adoption.

Table 10: Empirical Studies of Blockchain Adoption in Education

Study	Research Design	Factors Influencing Adoption	Barriers to Adoption
Fedorova & Skobleva (2020)	Qualitative: interviews	No	Yes
Kosmarski (2020)	Qualitative: interviews and focus groups	No	Yes
El Nokiti and Yusof (2019)	Qualitative: focus groups	Yes	No
Ullah et al. (2020)	Quantitative: survey	Yes	No
Widjaja et al. (2020)	Qualitative: interviews	Yes	No

Several important observations arise from the review. On a positive side, there seems to be a growing interest in blockchain applications for education. The studies covered a wide range of applications, both existing and potential. There is also growing evidence of working blockchain models for education institutions with dozens adopting and applying blockchain solutions for various purposes. At the same time, the research remains dominated by review papers and conceptual models. There is a limited number of papers outside the major research areas, which are certificates/diplomas and blockchain for administrative purposes such as admissions, management of transcripts and student records. Blockchain applications for learning processes seem to be gaining interest, although the number of such papers remains disproportionately small. As such, the research remains misbalanced in terms of topics and conceptual versus real-life applications. Finally, it is clear that the field lacks empirical research and case analyses of blockchain adoption in education. In the absence of strong empirical evidence of blockchain benefits for different education areas as well as the processes behind adoption and the factors driving it, many institutions may remain cautious regarding blockchain.

2.5 Reasons to Adopt Blockchain in Education

Blockchain, as any other novel technology, has been thoroughly analysed by the researchers to identify the reasons for its adoption in education. In essence, studies offering an analysis of reasons to adopt answer the question as to why blockchain should be integrated into education environments. In total, 33 papers in the review listed specific adoption reasons. The discussions of blockchain adoption reasons commonly follow reviews of typical problems faced by educational institutions today. Among these are: problems associated with physical credential confirmations and single points of failure; problems associated with academic data storage and exchange; problems associated with academic fraud and others (Alammary et al., 2019; Chen et al., 2018; Kamisalic et al., 2020; Gresch & Camillieri, 2017; Yumna et al., 2019). Accordingly, researchers view the benefits of blockchain adoption for both education institutions and students. A summary of these is presented in Table 11.

Table 11: Reasons to Adopt Blockchain in Education Identified in Literature

Reasons to Adopt	**Specific Benefits**	**Studies**
Organisation-focused	-Reduced cost of operations	(Awaji, Solaiman, & Albshri, 2020), (Ma & Fang, 2020), (Holotescu, 2018)
	-Reduced cost of data management	(Bhaskar, Tiwari, & Joshi, 2020), (Kant & Anjali, 2020), (Eaganathan, Indrian, & Nathan, 2019), (Liu, et al., 2021), (El Nokiti & Yusof, 2019)
	-Reduced administrative personnel requirements	(Alammary, Alhazmi, Almasri, & Gillani, 2019), (Lindenmoyer & Fischer, 2019), (Yumna, Khan, Ikram, & Ilyas, 2019), (Turkanovic, Holbl, Kosic, Hericko, & Kamisalic, 2018)
	-Automation of processes	(Haugsbakken & Langseth, 2019)
	-Enhanced data security	(Bhaskar, Tiwari, & Joshi, 2020), (Alammary, Alhazmi, Almasri, & Gillani, 2019), (AlHarthy, AlShuhaimi, & AlIsmaili, 2019), (Jirgensons & Kapenieks, 2018), (Abreu, Coutinho, & Bezerra, 2020), (Eaganathan, Indrian, & Nathan, 2019), (Liu, et al., 2021), (El Nokiti & Yusof, 2019)
	-Reduced bureaucracy	(Haugsbakken & Langseth, 2019)
Student-focused	-New methods of course delivery and assessment	(Alammary, Alhazmi, Almasri, & Gillani, 2019), (Williams, 2019), (El Nokiti & Yusof, 2019)
	-Stronger collaborative student-student and student-instructor environments	(Loukil, Abed, & Boukadi, 2021), (Novotny, et al., 2018)
	-Better organization of	

	knowledge and learning process	(Raimundo & Rosario, 2021)
	-"Learning is earning" approach	(Chen, Xu, Lu, & Chen, 2018), (Sahonero-Alvarez, 2018), (Lizcano, Lara, White, & Aljawarneh, 2020), (Kontzinos, et al., 2019)
	-Reduced cost of education for students	(Kant & Anjali, 2020), (Castro & Au-Yong-Oliveira, 2021)
Organization and student focused	-Immutable, easily verifiable academic credentials	(Bhaskar, Tiwari, & Joshi, 2020), (Raimundo & Rosario, 2021), (Loukil, Abed, & Boukadi, 2021), (Yumna, Khan, Ikram, & Ilyas, 2019), (Arndt & Guercio, 2020), (Abreu, Coutinho, & Bezerra, 2020), (Lizcano, Lara, White, & Aljawarneh, 2020), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (Ocheja, Flanagan, Ueda, & Ogata, 2019)
	-Reduced academic fraud	(Alammary, Alhazmi, Almasri, & Gillani, 2019), (Castro & Au-Yong-Oliveira, 2021), (Chen, Xu, Lu, & Chen, 2018), (Widjaja, Cassandra, Widjaja, Prabowo, & Fernando, 2020), (Nurhaeni, Handayani, Budiarty, Apriani, & Sunarya, 2020)
	-Enhanced privacy and data ownership	(Bhaskar, Tiwari, & Joshi, 2020), (Alshahrani, Beloff, & White, 2020), (Lee & Park, 2021), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (El Nokiti & Yusof, 2019)

From a purely organisational standpoint, blockchain is often associated with operational efficiencies and improvements of administration processes. Reducing the costs of operations is often related to the distributive and immutable nature of blockchain (Awaji, Solaiman, & Albshri, 2020; Holotescu, 2018; Ma & Fang, 2020). It enables costs to be saved on data management (Bhaskar et al., 2020; Eaganathan et al., 2019; El Nokiti & Yusof, 2019; Kant & Anjali, 2020; Liu et al., 2020), a reduction in the required administrative personnel (Alammary et al. 2019; Lindenmoyer & Fischer, 2019; Turkanovic et al., 2018) and the automation of certain operations (Haugsbakken & Langseth, 2019). Finally, blockchain is often regarded as a next step in data security, which is more efficient and reliable than the existing database approaches (Abreu et al., 2020; Alammary et al., 2019; AlHarthy et al., 2019; Bhaskar et al., 2020; Eaganathan et al., 2019; El Nokiti & Yusof, 2019; Jirgensons & Kapenieks, 2018; Liu, et al., 2021).

In terms of student-centred advantages, researchers pointed out to blockchain's ability to improve the overall quality of education and contribute to contemporary education development (Cahyadi et al., 2021; Nurhaeni et al., 2020). Blockchain is regarded as a means to enhance learning environments through new methods of course delivery and assessment (Alammary et al., 2019; El Nokiti & Yusof, 2019; Williams, 2019), facilitating stronger collaborative student-student and student-instructor environments (Loukil et al., 2021; Novotny, et al., 2018) and better organisation of knowledge and learning process (Raimundo & Rosario, 2021). An important related innovation offered by blockchain is the concept of "learning is earning" where institutions can create a form of cryptocurrency to track student progress and offer rewards (Chen, Xu, Lu, & Chen, 2018; Kontzinos, et al., 2019; Lizcano, Lara, White, & Aljawarneh, 2020; Sahonero-Alvarez, 2018). Several authors also noted an opportunity to reduce the cost of education for students (Castro & Au-Yong-Oliveira, 2021; Kant & Anjali, 2020).

Finally, a wide array of benefits from adopting blockchain in education falls into the mutual category for students and organizations. They are often linked to a new, unique type of trust mechanism that blockchain can offer (Caldarelli & Ellul, 2021; Novotny et al., 2018). For example, the distributed nature of blockchain is also considered a great contribution to the security and transparency of academic achievements and credentials. Specifically, researchers pointed to immutable blockchain-secured diplomas which can be easily verified and shared between education institutions and employers (Abougalala et al., 2020; Abreu et al., 2020; Arndt & Guercio, 2020; Bhaskar et al., 2020; Lizcano et al., 2020; Loukil et al., 2021; Ocheja et al., 2019). Reducing academic fraud and stronger identity authentication are also considered important reasons to adopt blockchain in education (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Castro & Au-Yong-Oliveira, 2021), (Chen, Xu, Lu, & Chen, 2018), (Widjaja, Cassandra, Widjaja, Prabowo, & Fernando, 2020), (Nurhaeni, Handayani, Budiarty, Apriani, & Sunarya, 2020). Likewise, researchers noted that a beneficial feature of blockchain for both students and institutions is the ability to enhance privacy and data ownership (Bhaskar, Tiwari, & Joshi, 2020), (Alshahrani, Beloff, & White, 2020), (Lee & Park, 2021), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (El Nokiti & Yusof, 2019).

2.6 Adoption Barriers

Barriers to blockchain adoption in education have been well explored in the literature. These barriers can be categorised as: technology related, organization related, and environment related.

Technology-related barriers to blockchain adoption have been discussed in terms of innate blockchain features and technology novelty (Table 12). Scalability of blockchain was the most often mentioned issue, as the existing blockchains demonstrate reduced performance levels for continuously expanding data (Bhaskar, Tiwari, & Joshi, 2020), (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Awaji, Solaiman, & Albshri, 2020), (Loukil, Abed, & Boukadi, 2021), (Ma & Fang, 2020), (Sharma & Batth, 2020), (Yue, Xiaofeng, & Huagang, 2020), (Yumna, Khan, Ikram, & Ilyas, 2019), (Caldarelli & Ellul, 2021), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (Ismail, Hameed, AlShamsi, AlHammady, & Aldhandhani, 2019), (Ocheja, Flanagan, Ueda, & Ogata, 2019). Transaction speed and processing time are seen as problems related to this (Chen, Xu, Lu, & Chen, 2018), (Ma & Fang, 2020), (Sharma & Batth, 2020), (Yue, Xiaofeng, & Huagang, 2020), (Williams, 2019), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (Ismail, Hameed, AlShamsi, AlHammady, & Aldhandhani, 2019). Many researchers also mentioned problems related to the compatibility of blockchain with existing systems (Raimundo & Rosario, 2021), (Awaji, Solaiman, & Albshri, 2020), (Sharma & Batth, 2020), (Castro & Au-Yong-Oliveira, 2021), (Liu & Zhu, 2021), (Pfeiffer, Bezzina, Wernbacher, & Kriglstein, 2020). There is a concern that a battle of blockchain formats will eventually ensue, resulting in incompatible platforms and difficulties of data sharing (Gresch & Camilleri, 2017), (Cahyadi, Faturahman, Haryani, Dolan, & Millah, 2021).

Several authors discussed the adoption barriers arising from the innate characteristics of blockchain. The immutability feature, for example, was considered detrimental in cases related to diploma revocation or expiration (Bhaskar, Tiwari, & Joshi, 2020), (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Raimundo & Rosario, 2021), (Awaji, Solaiman, & Albshri, 2020), (Loukil, Abed, & Boukadi, 2021), (Yumna, Khan, Ikram, & Ilyas, 2019), (Castro & Au-Yong-Oliveira, 2021), (Vidal, Gouveia, & Soares, 2019). Likewise, the transparent decentralised nature of blockchain was seen by some authors as a threat to privacy of academic information (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Raimundo & Rosario, 2021), (Awaji, Solaiman, & Albshri, 2020), (Ma & Fang, 2020), (Yumna, Khan, Ikram, & Ilyas, 2019), (Caldarelli & Ellul, 2021), (Castro & Au-Yong-Oliveira, 2021), (Pfeiffer, Bezzina, Wernbacher, & Kriglstein, 2020), (Ocheja, Flanagan, Ueda, & Ogata, 2019).

Some scholars also discussed high levels of energy consumption required to run blockchain (Chen, Xu, Lu, & Chen, 2018), (Gresch & Camilleri, 2017), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020). Ghaffar & Hussain (Ghaffar & Hussain, 2019) also mentioned a unique negative aspect called private key loss conundrum which makes it impossible to recover/change blockchain data if a private key is lost.

Finally, a number of studies pointed to the technology newness, claiming its immaturity and the lack of both theory and real data for applications in education (Bhaskar, Tiwari, & Joshi, 2020), (Alammary, Alhazmi, Almasri, & Gillani, 2019), (AlHarthy, AlShuhaimi, & AlIsmaili, 2019), (Yue, Xiaofeng, & Huagang, 2020), (Williams, 2019), (Kosmarski, 2020).

Table 12: Technology Barriers to Blockchain Adoption in Education

Barriers	Studies
Scalability	(Bhaskar, Tiwari, & Joshi, 2020), (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Awaji, Solaiman, & Albshri, 2020), (Loukil, Abed, & Boukadi, 2021), (Ma & Fang, 2020), (Sharma & Batth, 2020), (Yue, Xiaofeng, & Huagang, 2020), (Yumna, Khan, Ikram, & Ilyas, 2019), (Caldarelli & Ellul, 2021), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (Ismail, Hameed, AlShamsi, AlHammady, & Aldhandhani, 2019), (Ocheja, Flanagan, Ueda, & Ogata, 2019)
Transaction speed over growing data	(Chen, Xu, Lu, & Chen, 2018), (Ma & Fang, 2020), (Sharma & Batth, 2020), (Yue, Xiaofeng, & Huagang, 2020), (Williams, 2019), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (Ismail, Hameed, AlShamsi, AlHammady, & Aldhandhani, 2019)
Compatibility with legacy systems	(Raimundo & Rosario, 2021), (Awaji, Solaiman, & Albshri, 2020), (Sharma & Batth, 2020), (Castro & Au-Yong-Oliveira, 2021), (Liu & Zhu, 2021), (Pfeiffer, Bezzina, Wernbacher, & Kriglstein, 2020)
Different blockchain platforms / formats' clash	(Gresch & Camilleri, 2017), (Cahyadi, Faturahman, Haryani, Dolan, & Millah, 2021)
Immutability over expired/revoked credentials	(Bhaskar, Tiwari, & Joshi, 2020), (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Raimundo & Rosario, 2021), (Awaji, Solaiman, & Albshri, 2020), (Loukil, Abed, & Boukadi, 2021), (Yumna, Khan, Ikram, & Ilyas, 2019), (Castro & Au-Yong-Oliveira, 2021), (Vidal, Gouveia, & Soares, 2019).
Privacy over transparent nature of blockchain	(Alammary, Alhazmi, Almasri, & Gillani, 2019), (Raimundo & Rosario, 2021), (Awaji, Solaiman, & Albshri, 2020), (Ma & Fang, 2020), (Yumna, Khan, Ikram, & Ilyas, 2019), (Caldarelli & Ellul, 2021), (Castro & Au-Yong-Oliveira, 2021), (Pfeiffer, Bezzina, Wernbacher, & Kriglstein, 2020), (Ocheja, Flanagan, Ueda, & Ogata, 2019)
Technology newness	(Bhaskar, Tiwari, & Joshi, 2020), (Alammary, Alhazmi, Almasri, & Gillani, 2019), (AlHarthy, AlShuhaimi, & AlIsmaili, 2019),

	(Yue, Xiaofeng, & Huagang, 2020), (Williams, 2019), (Kosmarski, 2020)
High level of energy consumption	(Chen, Xu, Lu, & Chen, 2018), (Gresch & Camilleri, 2017), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020)
Private key loss conundrum	(Ghaffar & Hussain, 2019)

The identified organisational barriers to blockchain adoption in education are related to costs of implementation, insufficient knowledge, and possible resistance to change (Table 13). Researchers noted the high level of out-of-pocket costs for blockchain implementation as well as supplemental costs for system maintenance (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Awaji, Solaiman, & Albshri, 2020), (Yue, Xiaofeng, & Huagang, 2020) and increasingly high resource use (Gresch & Camilleri, 2017). Potential issues with financing and infrastructure were also discussed by Cahyiadi et al. (Cahyadi, Faturahman, Haryani, Dolan, & Millah, 2021). Likewise, a number of researchers pointed to a general lack of understanding of blockchain by both educators and school administrators (Yue, Xiaofeng, & Huagang, 2020), (Williams, 2019), (Pfeiffer, Bezzina, Wernbacher, & Kriglstein, 2020), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020). Ma and Fang (Ma & Fang, 2020) also mentioned that for many education institutions, the implementation of blockchain is difficult because of lack of skilled specialists in this area whereas Fedorova and Skobleva (Fedorova & Skobleva, 2020) noted a general lack of awareness of blockchain and its benefits among decision makers in the educational sector. In addition, blockchain is often perceived as too complex (Castro & Au-Yong-Oliveira, 2021), (Liu & Zhu, 2021), (Gresch, Rodrigues, Scheid, Kanhere, & Stiller, 2018), bringing new dependencies on third parties (Gresch, Rodrigues, Scheid, Kanhere, & Stiller, 2018), and blurring property rights (Ma & Fang, 2020). Finally, some researchers were concerned about the possible conflict of values for those seeking to preserve traditional education approaches (Alammary, Alhazmi, Almasri, & Gillani, 2019), (Fedorova & Skobleva, 2020), (Kosmarski, 2020). These individuals may be resistant to blockchain adoption.

Table 13: Organisational Barriers to Blockchain Adoption in Education

Barriers	**Studies**
Initial costs and maintenance costs	(Alammary, Alhazmi, Almasri, & Gillani, 2019), (Awaji, Solaiman, & Albshri, 2020), (Yue, Xiaofeng, & Huagang, 2020), (Gresch & Camilleri, 2017), (Cahyadi, Faturahman, Haryani, Dolan, & Millah, 2021)

Perceived complexity	(Yue, Xiaofeng, & Huagang, 2020), (Williams, 2019), (Pfeiffer, Bezzina, Wernbacher, & Kriglstein, 2020), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020)
Conflict of values	(Alammary, Alhazmi, Almasri, & Gillani, 2019), (Fedorova & Skobleva, 2020), (Kosmarski, 2020)
Lack of skilled personnel	(Ma & Fang, 2020)
Lack of technology awareness	(Fedorova & Skobleva, 2020)
Dependencies on third parties	(Gresch & Camilleri, 2017)
Blurred property rights	(Ma & Fang, 2020)

Finally, environment adoption barriers (Table 14) are mostly viewed through the prism of the lack of a regulatory environment (Fedorova & Skobleva, 2020) and the lack of clarity regarding compliance with privacy laws (Vidal, Gouveia, & Soares, 2019). This may result in possible legal issues for education institutions (Loukil, Abed, & Boukadi, 2021), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (Kosmarski, 2020). Cahyadi et al. (Cahyadi, Faturahman, Haryani, Dolan, & Millah, 2021) also pointed to the lack of standardization in blockchain technology for education, while Ma and Fang (Ma & Fang, 2020) discussed the lack of general policy guidance and protection mechanisms.

Table 14: Environmental Barriers to Blockchain Adoption in Education

Barriers	**Studies**
Lack of regulatory environment	(Fedorova & Skobleva, 2020)
Lack of clarity regarding privacy	(Vidal, Gouveia, & Soares, 2019)
Possible problems with laws' compliance	(Loukil, Abed, & Boukadi, 2021), (Abougalala, Amasha, Areed, Alkhalaf, & Khairy, 2020), (Kosmarski, 2020)
Lack of standardization mechanisms	(Cahyadi, Faturahman, Haryani, Dolan, & Millah, 2021)
Lack of policy guidance and protective measures	(Ma & Fang, 2020)

2.7 Adoption Factors

Factors influencing the adoption of blockchain by education institutions, unlike the barriers hitherto, remain a relatively unexplored area. Only 8 studies in the sample discussed factors that would positively influence blockchain adoption in education. Institutional cooperation was discussed in 5 studies (Eaganathan et al., 2019; Gresch & Camilleri, 2017; Lizcano et al., 2020; Ocheja et al., 2019; Widjaja et al., 2020). Gresch & Camilieri (2017) also mentioned that state-level cooperation on the standardization of blockchain mechanisms should influence the speed of adoption. Widjaja et al. (2020) and El Nokiti and Yusof (2019) pointed to the need of raising blockchain awareness and knowledge for application in education. Yue et al. (2020) proposed that influential blockchain adoption mechanisms would include the development of safe and reliable rules of use, creating an efficient technology transition path, establishing mechanisms for open data sharing, and reforming the education management system. However, Ullah et al. (2020) conducted the only empirical study to examine the influence of adoption factors. Trialability, compatibility, and relative advantage were confirmed as positive influencers of blockchain adoption in education both directly and via perceived usefulness and perceived ease of use.

Therefore, it can be concluded that there is a clear lack of empirical research on the factors influencing the adoption of blockchain in education. Ullah's study was a welcoming addition to the existing knowledge, although it only offered an empirical investigation of blockchain adoption factors at an individual level. For the most part, it is education administrators who make decisions related to new technology trials and adoption in industry. Therefore, more empirical research on organisational factors is required. This represents an important area for investigations in the future, especially given the relatively slow pace of the adoption of blockchain in this field.

2.8 Theoretical Frameworks of Adoption

While multiple conceptual frameworks for blockchain implementation have been proposed, only one study in the sample applied an established theoretical framework for blockchain adoption in education. Ullah et al. (2020) used an integrated Technology Acceptance – Diffusion of Innovations (TAM-DOI) framework to examine blockchain acceptance in smart learning environments. However, the framework only examined individual-level factors related to how blockchain is perceived by users. The lack of theoretical grounding for blockchain adoption in education can be explained by its relative immaturity.

To some extent, the adoption of blockchain in education could be examined through the theoretical lens of general blockchain adoption frameworks developed with no specific link to a particular industry (Table 15). The Technology-Organization-Environment (TOE) framework and its expansions are the most popular in this regard, although some authors also proposed to explore adoption factors through the lens of the Theory of Reasoned Action (TRA) and a value driver perspective. It is difficult to predict the explanatory power of these frameworks since they do not consider education environment specifics. Overall, theory development for blockchain adoption in education offers a relatively unexplored but potentially rather fertile ground for further research.

Table 15: General and Education Industry Specific Blockchain Adoption Frameworks

Study	Framework Type	Theory or Perspective Used	Factors Considered
Angelis & Da Silva (2019)	General	Value driver perspective	Value opportunities (9 factors), value drivers (4 factors), technology feasibility and viability (7 factors)
Barnes & Xiao (2019)	General	TOE	Technological (5 factors), organisational (4 factors), environmental (5 factors)
Clohessy et al. (2020)	General	TOE enhanced	Technological (15 factors), organisational (13 factors), environmental (12 factors), task-related (12 factors), individual (13 factors)
Janssen et al. (2020)	General	TOE variation	Institutional (3 factors), market (3 factors), technology (3 factors)
Li (2020)		TRA-TAM	Perceived usefulness, perceived ease of use, perceived trend, subjective norms, attitude to adopt, intention to adopt
Toufaily et al. (2021)	General	TOE	Technological (8 factors), organisational (3 factors), environmental (3 factors)
Ullah et al. (2020)	Specific	TAM-DoI	Trialability, relative advantage, compatibility, ease of use, perceived usefulness

2.9 Search Limitations

The study results should be considered within several limitations. One possible limitation is the number of databases selected for the extraction of the studies. On the one hand, it is physically difficult to review all possible sources of literature online in a limited amount of time. On the other hand, we believe that the selected databases, due to their reputation and scale, provide a good collection of research on the topic which is both illustrative and encompassing. This study also used an established, practical approach to filtering the literature which helped resolve possible literature selection biases. Another limitation is the rapid nature of change that blockchain may bring to the education industry. As such, the study findings may soon require updating. However, the usefulness of this research may also be seen by comparing the state of blockchain adoption at this and later points in time. This would allow the progress of technology adoption to be tracked, as well as the practical and theoretical developments that it brings. Finally, as is the case with many reviews, this study offers conclusions based on the researchers' subjective opinions. However, the study did not aim to measure the actual adoption of blockchain in education institutions or the state of such adoption. Instead, it aimed to organise the existing knowledge on the topic and point to the gaps in this knowledge. In this regard, the findings of the study are rather useful in guiding empirical studies in the future.

2.10 Research Gaps

The systematic literature review in Chapter 2 highlighted some important gaps that exist in the literature on blockchain adoption in higher education:

1. The studies on blockchain technology adoption in education are limited. Studies in the education sector represent a fraction of studies on blockchain adoption in other sectors like finance, supply chains and logistics and healthcare. This demonstrates the need to expand the body of knowledge on blockchain adoption in the education sector.

2. The majority of knowledge on blockchain adoption so far has been formed through review studies and conceptual models. They cover either existing or potential uses of blockchain without paying particular attention to combinations of factors that promote or impede it. This demonstrates the need to explore such factors.

3. There are very few studies that present theoretically well-founded models of blockchain adoption in education. An analysis of the relevant literature suggests the absence of a theoretical-based study that serves as a guide in developed and developing countries to explain blockchain adoption in higher education. This demonstrates the need to further explore the relevant adoption theories to better describe the process, present and empirically test such theoretical frameworks.

4. There is a dearth of qualitative research on the topic of blockchain adoption in higher education. However, qualitative research is very useful in describing blockchain perceptions of education administrators, users (students/instructors), and technology experts. These can be compared to the actual state of technology

in educational institutions that successfully adopted and used it.

5. To the best knowledge of the author, there is no current work on adopting blockchain technology in higher education performed in Arab countries, particularly in KSA. Saudi researchers so far have focused almost exclusively on reviews of blockchain adoption cases abroad. This demonstrates the need to conduct blockchain adoption research in the Saudi context.

From the gaps identified in the existing literature on blockchain adoption in higher education, it follows that there is a need to explore the factors that promote and impede the adoption process. Further, it follows that such factors need some clear dimensional classification and grouping for ease of comprehension, review, and actionability. The existing studies that applied adoption frameworks were analysed along the following dimensions: technology, organisational, environmental, and quality/value (Table 16). Therefore, this study considers these four dimensions as influential in the adoption process.

Table 16: Factor Dimensions in Blockchain Adoption Studies

Study	Framework	Factor Dimensions			
		Technology	Organisation	Environment	Quality
Angelis & Da Silva (2019)	Value drivers	x			x
Barnes & Xiao (2019)	TOE	x	x	x	
Clohessy et al. (2020)	TOE	x	x	x	x
Janssen et al. (2020)	TOE	x	x	x	
Li (2020)	TRA				x
Toufaily et al. (2021)	TOE	x	x	x	
Ullah et al. (2020)	TAM-DoI	x			x

2.11 Chapter Summary

This chapter sought to provide an up-to-date relevant picture of the contemporary status of research on blockchain adoption in education. Based on the review of 107 studies, a taxonomy of the research was developed which offers an organised, ordered view on the state of research – something which was lacking in the previous literature reviews on the topic. The taxonomy contributes to the research field by offering a roadmap for future studies based on easily identifiable gaps in research and knowledge.

Overall, the reviewed literature demonstrated the expanding research on blockchain adoption in education. However, the majority of knowledge on blockchain adoption so far has been formed through review studies and conceptual models. While they offer important insights and present potentially viable technical solutions, they do not provide useful information on what factors contribute to the adoption process. Nevertheless, a knowledge of such factors can benefit organisational decision makers who may consider blockchain applications but remain unsure of their usefulness and potential for their institutions. Perhaps the lack of practical information on blockchain adoption is the reason why many administrators lack motivation for blockchain adoption and prefer a wait-and-see strategy (Ma & Fang, 2020). Therefore, it is necessary for researchers to provide more data on actual adoption cases and explore the factors contributing and/or impeding the adoption process.

Several research avenues arise from here. First, simple reviews of use cases may not be sufficient to offer a good practical view of the adoption process. Case studies of successful blockchain adoption as well as action research could provide practical insights into the process and its outcomes and serve as a viable approach to transfer actual industry experience to academic research. This, in turn, will enable a systematic view of the adoption process to be formed and avoid trial-and-error approaches to adoption in educational settings. Second, this review identified only 5 empirical investigations of blockchain adoption, and only one of them was quantitative research. Obviously, this is very insufficient for such a dynamically developing field. Qualitative research can be useful in this regard by investigating blockchain perceptions from education administrators, users (students/instructors), and technology experts. These can be compared to the actual state of technology in educational institutions that successfully adopted and used it. Further, the field clearly lacks a strong theoretical grounding for the adoption process. This is in deep contrast to, for example, supply chain management where several adoption theories have been successfully introduced and tested (Alazab et al., 2021; Choi et al., 2020; Kouhizadeh et al., 2021; Queiroz & Wamba, 2019).

Producing a strong theoretical framework for blockchain adoption in higher education will serve as a good foundation for empirical research in the field. One major gap in the knowledge in this regard is the absence of a holistic blockchain adoption framework which is empirically tested to identify the effect of various types of factors (technology, organisational, environmental and quality). To the best knowledge of the author, there is no such framework for the Saudi higher education context. The next chapter defines the research problem based on the identified research gaps and outlines the key research question and subquestions.

3 Problem Definition

3.1 Introduction

This chapter presents the problem definition that guides the research process in this study. Section 3.2 outlines the key definitions of the terms used in the chapter. Section 3.3 outlines the key research questions to be addressed in the study. Section 3.4 presents the main study objectives guided by the research problem and questions.

3.2 Key Definitions

Given below is the list of the key terms used in this chapter.

Blockchain: a decentralized, digital ledger that records transactions in a secure, transparent and permanent manner. It operates through a network of computers, where each block in the chain contains a list of transactions that are verified and added to the chain through cryptography. This makes the data stored in a blockchain immutable and resistant to tampering, creating a trustless system without the need for intermediaries. Blockchain technology is primarily used in the context of cryptocurrencies, but it has potential applications in various fields including higher education (Alammary, Alhazmi, Almasri, & Gillani, 2019).

Higher Education Institution (HEI): an organisation that offers post-secondary education leading to a degree or professional qualification. These institutions typically provide programs of study at the undergraduate and graduate level, and usually include universities, colleges, community colleges and technical schools (Alenezi, 2021).

Holistic Framework: a comprehensive approach to problem solving or decision making that takes into account all relevant aspects and factors, rather than just a single isolated aspect. This type of framework aims to provide a complete and integrated perspective, considering the interconnections and relationships between various elements, to arrive at a well-rounded solution or conclusion.

Technological Factors: features of a specific technology that define it and may influence its adoption and use. This study looks into a set of technology factors outlined in the Diffusion of Innovation theory by Rogers (1995).

Organisational Factors: the internal characteristics of an organisation that can affect its operation and performance, the way an organisation functions, its ability to adapt to change, and its ability to achieve its goals and objectives. In the context of technology adoption, organisational factors play a critical role in determining whether a technology in question represents a good fit with the organisation. This study considers the organisational factors outlined by Tornatzky et al. (1990).

Environmental Factors: the institutions and processes that create the broad context of organisational operations. While they exert a certain influence on organisations, the organisations do not have the power to influence them in return. Some examples are market conditions, competitive action, national culture and political environment. This study considers the organisational factors outlined by Tornatzky et al. (1990).

Quality Factors: the elements or attributes that determine the degree of excellence or merit of a product, service, or experience. These factors can vary depending on the industry, customer preferences, and the type of product or service being evaluated. In the context of higher education, quality factors play a critical role in determining students' satisfaction and can impact their competitiveness in the labour market (Harvey, 2007).

Barriers to adoption: the obstacles that prevent organisations from fully embracing and utilising new technology. These barriers can range from practical considerations such as cost, compatibility with existing systems, and ease of use, to more intangible factors such as resistance to change, lack of understanding, or cultural attitudes (Clohessy, Treiblmaier, Acton, & Rogers, 2020). Overcoming these barriers can be critical for organisations looking to remain competitive in an increasingly technology-driven world.

3.3 Research Questions

Based on the gaps identified in the literature, the main research question in this study is:

How can we develop a holistic blockchain adoption model for Saudi HEIs?

As previously discussed, there is no comprehensive model for blockchain adoption by HEIs in Saudi Arabia's context. Further, even though some attempts to develop such frameworks have been undertaken in other national contexts (see Table 15 in Section 2.10), the quantity and type of factors included in those models vary from study to study. This suggests that even though the grouping across dimensions remains more or less consistent, different factors would be included based on context. This study attempts to identify the specific factors in the context of Saudi Arabia HEIs. Accordingly, the following research sub-questions are formulated:

RQ1: Which technological factors influence Saudi higher education institutions' intention to adopt blockchain technology?

RQ2: Which organisational factors influence Saudi higher education institutions' intention to adopt blockchain technology?

RQ3: Which environmental factors influence Saudi higher education institutions' intention to adopt blockchain technology?

RQ4: Which quality factors influence Saudi higher education institutions' intention to adopt blockchain technology?

In addition to the factors that enable blockchain adoption in higher education settings, there are also a number of barriers that prevent or slow it down. As discussed in Section 2.6 of this thesis, these barriers can be categorised as: technology related, organisation related, and environment related. Again, however, there is no consistency in the types or number of barriers that pertain to each of the aforementioned dimensions. Therefore, the following research question and sub-questions are formulated:

RQ5: What are the barriers to adopting blockchain technology in Saudi higher education institutions?

- *What are the technology barriers?*
- *What are the organisational barriers?*
- *What are the environmental barriers?*

3.4 Research Objectives

Based on the main research question in this study, the primary objective is:

To develop a holistic blockchain adoption framework that can be practically applied by Saudi HEIs.

Given the gaps identified in the literature, this study aims to develop and validate a comprehensive adoption model for blockchain technology in the context of higher education in Saudi Arabia. While adoption models are already available in the literature, this research follows the major view that factors of adoption will vary depending on context. Initial qualitative research would help identify specific factors that could be relevant for the considered context. These, in turn, could be tested on a large population to determine the strength and direction of their relationship with adoption intent. To effectively meet the key objective formulated in this study, it is necessary to investigate the factors that influence (positively or negatively) the adoption of blockchain technology in Saudi HEIs across several dimensions. Accordingly, the accompanying objectives for the research are:

- *Develop an initial comprehensive model of blockchain technology adoption in Saudi higher education institutes based on the relevant theoretical foundations and empirical literature;*

This objective is met by reviewing the relevant technology adoption theories and selecting the relevant factors whose influence has been confirmed empirically in the studies on blockchain adoption in education.

- *Refine the model to fit with the context of Saudi higher education institutions;*

This objective will be met upon completion of Phase I of the research which involves interviews with the decision makers in Saudi HEIs. The analysis of the interviews will allow the factors found non-influential to be excluded and some new factors to be added, possibly not explored in the previous studies but found relevant in the context of Saudi HEIs. It is expected that some factors could be revised or combined for the same reasons.

- *Test the relationships within the finalised framework empirically to identify the factors influential in the blockchain adoption process by Saudi HEIs;*

This objective will be met upon completion of Phase II of the research which involves quantitative tests of the framework relationships. The analyses will show: 1) whether the model itself is fitting in exploring the adoption factors; and 2) what factors are influential in the adoption process within the selected context.

- *Based on the study findings, offer new insights of both theoretical and practical kinds to blockchain adoption and applications in higher education.*

This objective will be met by placing the study results within the existing body of knowledge on blockchain adoption in education. The results of the research will be compared to those reported in the literature and to the hypotheses formulated in this study. Particular attention will be given to discrepancies in the findings against expectations. Contributions to theory and practice will be reported.

3.5 Chapter Summary

This chapter introduced the research problem addressed in this study, presented the research question and formulated the key research objective. These were developed based on the gaps in the knowledge and research approaches identified in the course of the literature review. The key research objective posed in this study is to develop a practical holistic blockchain adoption framework for Saudi HEIs. Five research subquestions and corresponding objectives were formulated and explained. The next chapter provides an overview of the solution to the research problem based on the literature review of the relevant theories and approaches.

4 Solution Overview and Methodology

4.1 Introduction

This chapter presents a solution overview to the formulated research question and outlines the approach to implement it. Section 4.2 presents the definitions of the key technical terms used in the chapter. Section 4.3 describes the overall solution approach and the selection of the theories to form the foundation of the model for blockchain adoption in Saudi HEIs. Section 4.4 reviews the solutions aligning with research subquestions 1-5. Section 4.5 presents the research methodology and justifies a mixed methods design to test and validate the model. Section 4.6 details the process of model presentation and the initial analysis by a group of industry experts. Section 4.7 describes in detail the approach for model evaluation on a large sample of professionals from the Saudi higher education sector. Finally, Section 4.8 outlines the key procedures to ensure high ethical standards for the data collection and analysis.

Sections of this chapter have earlier been published in the following conference article:

Alalyan, M.S., Jaafari, N.A., Hussain, F.K. (2023). Technology factors influencing Saudi higher education institutions' adoption of blockchain technology: A qualitative study. *Advanced Information Networking and Applications (AINA)*.

4.2 Key Definitions

Presented below are the definitions of the key technical terms used in this chapter.

Theory: a set of interrelated concepts, definitions, and propositions that provide a systematic explanation of a phenomenon. Theories are developed based on empirical evidence and logical reasoning, and they are designed to be testable/falsifiable. The choice of a theory is important to contextualize and make sense of the findings, contributes to the advancement of knowledge, and improves the validity and reliability of the results (Creswell J. W., 2014).

Research Framework: the conceptual structure or blueprint that guides a research study. It includes the theoretical foundations, research questions, hypotheses, variables, methods, and data analysis techniques that shape the design and implementation of the study. A research framework provides a roadmap for conducting the research and helps ensure that the study is logically consistent, coherent and well-organised (Bryman, 2016).

Research Design: plan or strategy for conducting a study that involves collecting and analysing data to answer a specific research question. It outlines the methods, techniques, and procedures that will be used to collect and analyse data, and it provides a framework for conducting the study in a systematic, rigorous, and credible manner. The research design is an important component of the research process as it helps to ensure that the study is well-designed, appropriately executed, and that the results are reliable and valid (Creswell & Creswell, 2017).

Research Methodology: the specific procedures and techniques used in conducting a research study. It includes the design, data collection, data analysis, and interpretation of results, among other aspects. A research methodology provides a framework for carrying out a systematic and organised investigation and helps ensure that the study is rigorous and credible (Creswell J. , 2015).

Qualitative Research: a type of research that seeks to understand human behaviour and the reasons behind it. It focuses on the subjective experiences and perceptions of individuals, and often involves in-depth and open-ended data collection methods, such as interviews, focus groups, and observation. The aim of qualitative research is to provide a rich, detailed, and nuanced understanding of the experiences and perspectives of the participants, rather than to test a specific hypothesis or generate numerical data (Olfazoglu, 2017).

Quantitative Research: a type of research that uses numerical and statistical data to understand and describe phenomena. It involves the collection and analysis of quantitative data, through standardised and structured methods such as surveys, experiments or observations. The aim of quantitative research is to test hypotheses, identify relationships and patterns, and make generalisations about a larger population based on the results of the study. Quantitative research often uses statistical techniques to analyse the data and make inferences (Creswell & Creswell, 2017), and it is used in fields such as economics, psychology, sociology, and public health, among others, to provide a numerical understanding of the phenomena being studied.

Mixed Research: a type of research that combines both qualitative and quantitative research methods in a single study. This approach allows for the examination of a phenomenon from multiple perspectives and provides a more comprehensive understanding of the issue being studied. In mixed research, qualitative methods may be used to gain an in-depth understanding of a particular issue or phenomenon, while quantitative methods are used to test specific hypotheses and make generalisations about a larger population. This type of research design can be particularly useful in situations where the research question is complex and requires both a rich and detailed understanding of experiences and perspectives, as well as the ability to make quantifiable inferences and comparisons (Tashakkori, Johnson, & Teddlie, 2020).

4.3 Solution Overview

4.3.1 General Approach

This study follows the design science approach (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007) in developing the overall solution to the formulated research question. A six-step framework is demonstrated in Figure 9, along with the corresponding parts of the thesis. Each step is discussed below.

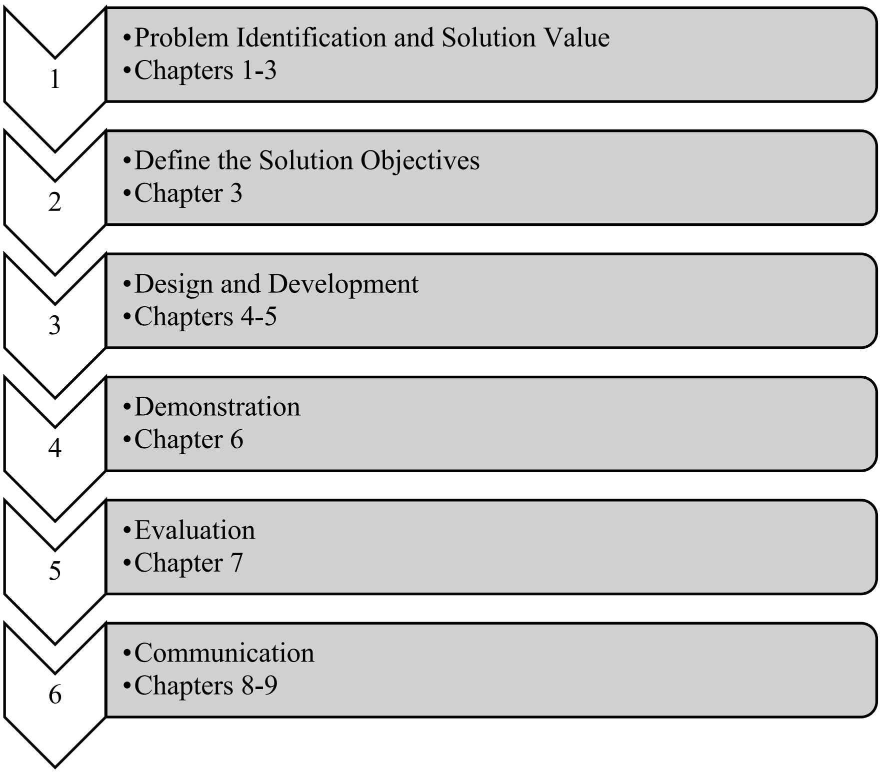


Figure 9: Approach to Problem Solution

Step 1: problem identification and solution value. In this step, the specific research problem was identified after a comprehensive literature review that allowed the existing knowledge gaps on blockchain adoption by HEIs to be determined (Chapter 2). Based on this, a key research question was formulated (Chapter 3). A granular view of the research question was provided given the complexity of the issue at hand and subquestions were formulated accordingly (Chapter 3). The value of the solution was presented initially in Chapter 1 where the role of novel technologies in higher education was discussed.

Step 2: define the solution objectives. In this step, the key objective was formulated on the basis of the main research question. The goal of the solution is to provide an actionable framework of blockchain adoption for Saudi HEI administrators. Several related objectives were formulated in Chapter 3 for a holistic approach to the issue. Resources to meet the objectives were discussed as well: available theoretical and empirical studies of adoption, industry experts' opinions, and a large-scale survey to confirm the role of specific model elements.

Step 3: design and development. In this step, the initial solution is created, which is an original blockchain adoption framework for Saudi HEIs. The development of the initial model is based on: 1) review and evaluation of the available theories and frameworks; 2) integration of the suitable theories; and 3) identification of the key model elements on the basis of theoretical and empirical studies. This process is thoroughly described in the remaining parts of Chapter 4. Chapter 5 then describes the original, conceptualised blockchain adoption framework and explains the relationships among its elements.

Step 4: demonstration. In this step, the initial model is demonstrated to a group of industry experts for review and evaluation. This constitutes Phase I of the research process, where the experts formulate professional opinions on the framework and its elements as well as propose additional elements which they deem appropriate for the context of Saudi HEIs. The key outcome of this step is a refined framework of blockchain adoption by Saudi HEIs. This step is undertaken in Chapter 6.

Step 5: evaluation. In this step, the refined model is tested on a large group of education and IT professionals from Saudi HEIs. This represents Phase II of the research process. The outcome of this step is the empirical evidence of how well the model explains blockchain adoption in Saudi HEIs as well as the efficacy of each predicted model element in this process. This step is detailed in Chapter 7.

Step 6: communication. The final step consists of summarising the research findings, analysing them and presenting them to the relevant audiences. A discussion of the research outcomes and conclusions is provided in Chapters 8 and 9 respectively. The literature review results have been communicated through a publication in a peer-reviewed journal. Additional publications are expected after the completion of the thesis.

As previously explained, the solution approach begins with the choice of the best fitting adoption theories which will form the foundation of the adoption model.

4.3.2 Theoretical Framework Choice

The positive impact of IT innovations on nearly every element of human life and organisational performance is well recognised and reported in the literature (Clohessy & Acton, 2019; O'Connor, Lowry, & Treiblmaier, 2020). The changes brought by innovative technologies became especially visible in the past few decades with the rapid development and integration of computers, the internet, mobile devices and telecommunications. This, in turn, increased the demand for theories and frameworks that could help understand how and why technological innovations are adopted and what factors play significant roles in the process (Khan & Qudrat-Ullah, 2020; Lai, 2017).

A number of theories and frameworks have been proposed to explain the phenomenon of adopting technology innovations. They focus on different underlying mechanisms of adoption which, in turn, leads to different factors considered influential. For this reason, it is necessary to have a comprehensive understanding of the popular models and theories, their key assumptions as well as the strengths and limitations to identify the one which fits the purpose and the context of this study best. Therefore, the following sections provide a critical review of several widely used technology adoption theories and frameworks. The rejected theories/models are reviewed first with an explanation of why they were deemed unfit for the study. Finally, the choice of the Diffusion of Innovations (Rogers, Diffusion of innovations, 1995) theory and Technology-Organisation-Environment (Tornatzky & Fleischer, 1990) framework as the foundations for this study is justified.

4.3.2.1 Social Cognitive Theory

Social Cognitive Theory (SCT) takes root in social psychology studies that focused on human actions and reactions to particular phenomena (Bandura, 1986). The theory views the adoption of innovation as an interplay of personal characteristics, behaviour and environment (Figure 10). Individual behaviours interact with personality through thoughts and actions; personal factors interact with the environment through the formation of beliefs and competencies; and behaviour interacts with the environment through the understanding and modification of actions.

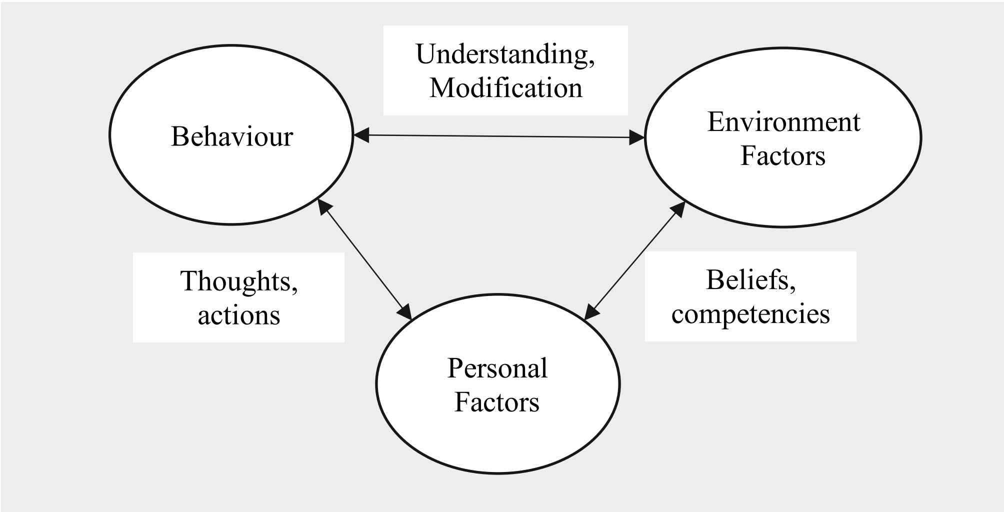


Figure 10: Social Cognitive Theory (Bandura, 1986)

SCT makes the proposition that individuals interact with the environment and their peers and receive feedback through which they learn and modify their further actions (Tarhini, Arachchilage, Masa'deh, & Abbasi, 2015). Bandura (1986) described it the following way:

> *Social cognitive theory distinguishes among three separable components in the social diffusion of innovation. The triadic model includes the determinants and mechanisms governing the acquisition of knowledge and skills concerning the innovation; adoption of that innovation in practice; and the social network by which innovations are promulgated and supported*. (p. 119)

Technology adoption in SCT is a type of social process and a product of gradual understanding of the innovation in question, acquiring skills for its use, and receiving positive feedback from personal networks and the environment. SCT is helpful in predicting adoption through individual and group behaviour change. It also takes into account the environment, which is important for studying innovations in different contexts. Yet, this theory is strongly positioned towards learning and personal actions, which is hardly surprising given its social study roots. On the other hand, it is not well-positioned with respect to technology because it ignores the effect of any potential technology characteristics. Further, SCT is focused on individuals, which makes it less appropriate for organisational settings which is the focus of this study. For these reasons, SCT was not considered as a theoretical foundation for this research.

4.3.2.2 Theory of Reasoned Action

Theory of Reasoned Action (TRA) was also originally developed for sociological and psychological research and later applied for information systems adoption studies (Taherdoost, 2018). The focus of TRA is on human behaviour which is seen as a product of rational decision making where implications of actions are considered (Ajzen & Fishbein, Understanding attitudes and predicting social behaviour, 1980). The process of forming particular behaviours as outlined by TRA is presented in Figure 11. Behaviour is represented by concrete actions that arise from behavioural intentions – a plan to engage in those actions. Behavioural intentions, in turn, are products of a combination of attitudes and subjective norms. Fishbein and Ajzen (1975) defined attitudes as the person's own evaluation of performing the intended action and subjective norms as perceptions of what close people would think of it. Accordingly, attitudes arise from personal beliefs while subjective norms from prevailing normative (social) beliefs.

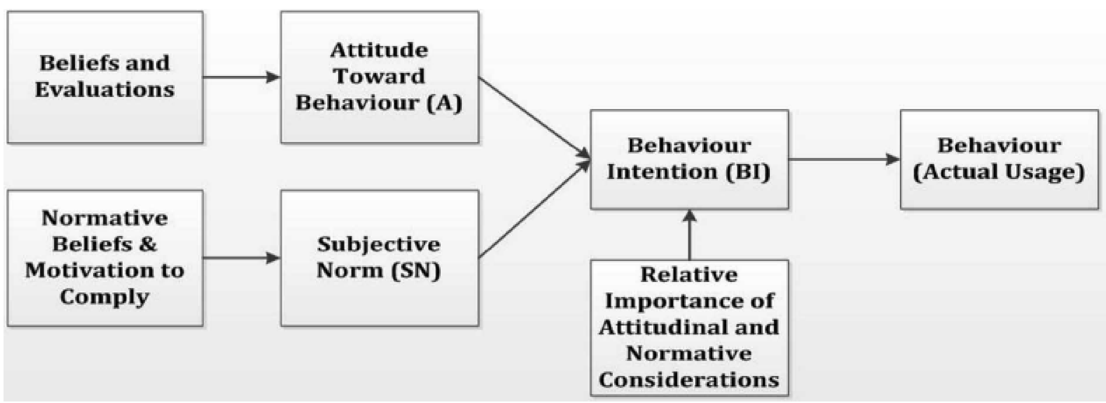


Figure 11: Theory of Reasoned Action (Ajzen & Fishbein, 1980)

From the perspective of TRA, technology adoption is the behavioural endpoint of the framework presented in Figure 11. The intent to use it would result from what individuals think about the technology themselves and what they believe others think about its use. Positive personal attitudes and subjective norms encourage intention to use. TRA can be considered more comprehensive than SCT in terms of internal drives to adopt an innovation. However, this comes at the expense of environmental factors since they are omitted from the framework. Environmental factors, as discussed above, are essential in considering technology adoption in different contexts. Further, as Tarhini et al. (2015) argued, TRA is a general model: it cannot be effectively adjusted to specific behaviours such as adoption of certain, non-conventional types of technologies. The model seems to be more appropriate for examining adoption of the already established technologies for which subjective norms and attitudes have been formed, which is not the case with emerging technologies like blockchain. Finally, like SCT, TRA focuses on individuals and ignores technological factors that could affect attitudes and, hence, intention to use technology. For these reasons, TRA was not considered as a theoretical foundation for the current study.

4.3.2.3 Theory of Planned Behaviour

Theory of Planned Behaviour (TPB) can be considered a modification of TRA: it was developed by the same researchers and introduced a single new element to the framework. According to Ajzen (1991), the purpose of the theory was to consider the absence of a complete volitional control over one's behaviour. To do this, TPB introduced a variable of Perceived Behaviour Control which is 'perceived ease or difficulty of performing the behaviour' (Ajzen, 1991, p. 188). This variable considers internal as well as external behavioural constraints that could impede action even in the presence of the right attitudes and subjective norms (Taylor & Todd, Decomposition and crossover effects in the theory of planned behavior: A study of consumer adoption intentions, 1995). In other aspects, TPB preserves the logic of TRA by considering attitudes and subjective norms as leading to behavioural intention and to actual behaviour in the end (Figure 12).

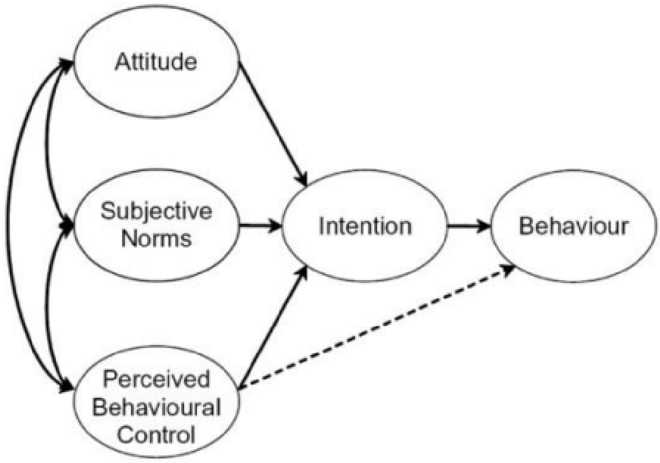


Figure 12: Theory of Planned Behaviour (Ajzen, 1991)

In the field of technology innovations, TPB not only considers personal attitudes and subjective norms in the adoption process, but also pays attention to what could limit one's behaviour. For example, a potential technology user would consider whether she has the required access and resources for technology use and meet the requirement criteria.

By introducing the notion of behavioural controls in the form of additional internal and external factors, TPB advanced TRA. It is also considered a more flexible model, and several extensions and modifications have actually been introduced to fit the needs of specific researchers (Conner & Armitage, 1998; Taylor & Todd, Decomposition and crossover effects in the theory of planned behavior: A study of consumer adoption intentions, 1995). Still, like its predecessor TRA, TPB concentrates on an individual user, their characteristics and behaviours while not considering technology factors or organisational characteristics. Further, even with the introduction of the control variable, the link between behavioural intention and actual behaviour has not been clearly established for this framework (Tarhini et al., 2015). Therefore, TPB was also rejected as a theoretical foundation for this study.

4.3.2.4 Task-Technology Fit

The TTF model (Figure 13) was developed by Goodhue and Thompson (1995) in response to the dominance of behaviour-oriented theories in information systems studies. The researchers proposed that a technology would be utilised as a result of the congruence of its characteristics with the tasks that individuals want to perform with it (Lai, 2017). The task-technology fit is a comprehensive measure that consists of eight factors: quality, locatability, authorisation, compatibility, ease of use/training, production timeliness, systems reliability and relationship with users (Goodhue & Thompson, 1995). Accordingly, a good task-technology fit is considered an indicator of improved task performance by technology users. Within TTF, users adopt blockchain because its inherent characteristics match the issues that users need to resolve: for example, blockchain's immutability feature matches the task of ensuring college certificate legitimacy and security.

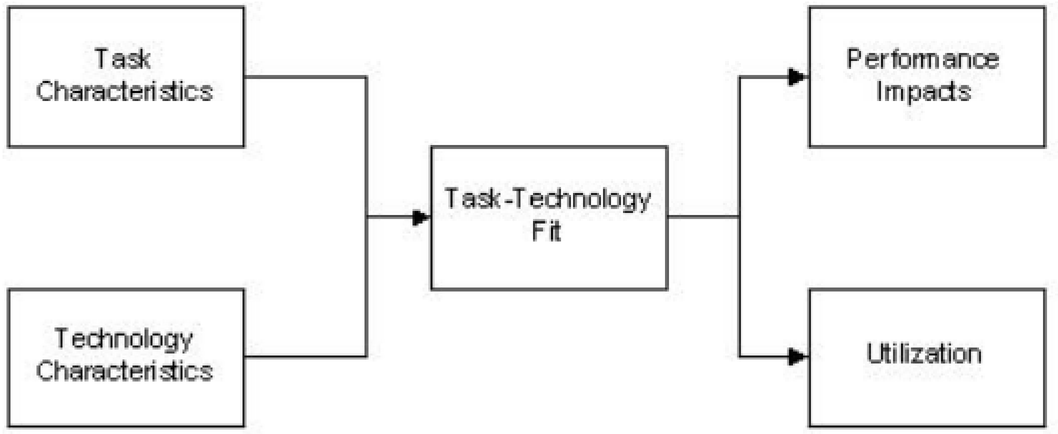


Figure 13: Task-Technology Fit Model (Goodhue & Thompson, 1995)

Unlike the behaviour-oriented theories reviewed above, TTF is a model that is: 1) more technology oriented and 2) considers tasks at hand as an important component of adoption. Furthermore, even though the original TTF was directed at individual users, its later adaptations also focused on group-level performances such as potential influence of technology on effectiveness and efficiency, quality of output and overall group satisfaction (Delgado Piña, María Romero Martínez, & Gómez Martínez, 2008; Zigurs & Buckland, 1998). This makes it potentially more adaptable for research at the organisational level. However, due to the focus on utilisation and performance, the model could be better suited to test for the outcomes of adoption rather than the process of adoption. Further, since the model assigns much importance to the task, it could be better suited to explore technology adoption for a specific organisational function rather than a comprehensive, organisation-wide project. While bringing technology factors into the limelight, TTF clearly ignores organisational and environment characteristics. Finally, it should be noted that empirical studies often provide inconsistent results for different technologies and contexts which makes the model difficult to generalise (Daradkeh, 2019;

Eybers, Gerber, Bork, & Karagiannis, 2019; Lin, Wu, Lim, Han, & Chen, 2019). For these reasons, TTF was not considered as a foundation for the current research.

4.3.2.5 Technology Acceptance Model and Its Variations

Technology Acceptance Model (TAM) arose from TRA, but it was developed with a specific focus on technology. The original idea for the model was proposed by Davis (1989) who stated that behavioural intention to use a technology arises from specific beliefs regarding the technology rather than generic attitudes. These beliefs were summarised within two key variables: perceived ease of use (PEOU) and perceived usefulness (PU) (Davis, 1993). The refined TAM envisioned behavioural acceptance of technology as a sequential process (Figure 14). According to the model, technology use arises from the intention to use, which is influenced by positive attitudes towards the technology. These, in turn, are predicted by whether the potential users believe that the technology is easy to use (PEOU) and beneficial (PU). The model further proposes that if a technology is perceived easy to use, it also influences the degree of its perceived usefulness. Finally, the perceived technology variables in the model are influenced by external factors which could be either technology related (such as system design, available documentation, technical support) or user related (such as enjoyment or training) (Agarwal & Karahanna, 2000; Davis, Bagozzi, & Warshaw, 1989). Earlier studies using TAM, however, showed that both PEOU and PU had a consistent direct effect on behavioural intention, which allowed the model to be simplified by eliminating the attitude variable (Venkatesh & Davis, A model of the antecedents of perceived ease of use: Development and test., 1996).

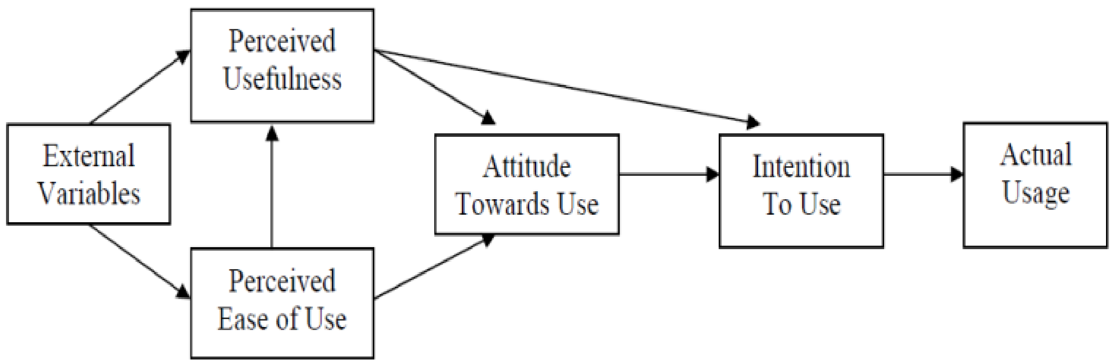


Figure 14: First Finalised TAM (Davis et al., 1989)

The development of TAM has contributed significantly to the analysis of user motivations in technology acceptance and actual use. The model has been validated multiple times across different types of technologies with excellent predictive results (Khan & Qudrat-Ullah, 2020; Taherdoost, 2018; Tarhini, Arachchilage, Masa'deh, & Abbasi, 2015). TAM also proved rather flexible in nature, as several extensions and modifications with various degrees of complexity have been introduced: A-TAM (Taylor & Todd, 1995), TAM2 (Venkatesh & Davis, 2000), UTAUT (Venkatesh, Morris, B, & Davis, 2003) and TAM3 (Venkatesh & Bala, 2008) being the most commonly mentioned and explored in the literature. The later models offered a very granulated view of the external factors that contribute to increased PEOU and PU. For example, TAM3 contains 13 factors either directly or indirectly influencing these two variables.

The contribution of TAM and its several versions to technology-related studies has been enormous. The model and its modifications is still being actively used by researchers in various fields, including studies of blockchain technology (Alazab, Alhyari, Awajan, & Abdallah, 2021; Kamble, Gunasekaran, & Arha, 2018; Wong, Tan, Lee, Ooi, & Sohal, 2020). It has been determined that up to 40% variability in behavioural intention to use technology could be explained by the combination of PEOU and PU (Lai, 2017; Tarhini, Arachchilage, Masa'deh, & Abbasi, 2015). This supports the strong predictive power of the constructs. Yet, TAM and its extensions also have drawbacks. First, it should be remembered that TAM is predominantly a model focused primarily on an individual user. TAM2 was intended to solve this issue by introducing additional job-related variables such as job relevance and output quality (Venkatesh & Davis, 2000). Still, these factors, even though within an organisational context, are applicable at an individual level. In other words, TAM does not consider technology adoption as an organisational goal to meet specific organisational needs. As such, it could be more appropriately used to analyse how organisational members, as end-users of technology, would accept and adopt it in the workplace. This is further confirmed by the absence even in the latest TAM versions of some common environmental factors that could influence organisational decision making in making technology investments (such as, for example, regulations and the presence of financial resources). Finally, TAM is mostly about the acceptance rather than the adoption of technology. Granted, the endpoint of the framework is actual technology use. However, the influence of all independent factors is on technology characteristics rather than on adoption or even behavioural intention to adopt. For these reasons, TAM was not considered for this study.

4.3.2.6 Diffusion of Innovations Theory

In many respects, Diffusion of Innovations Theory (DOI) (Rogers, Diffusion of innovations, 1995) is considered an important adoption theory in many fields when it comes to organisational level research (Lai, 2017; Tarhini, Arachchilage, Masa'deh, & Abbasi, 2015). The theory emerged from general observations of common elements that underlie diffusion research in several disciplines: sociology, psychology, communications, economics and organisational life (Alalyan, Jaafari, & Hussain, 2023; Rogers E. , 2003). Rogers formulated the DOI theory in his original book *Diffusion of Innovations* in 1962. The theory, in its basic, aims to explain the process of innovations spread and whether it has chances of being adopted (Fagan, 2001). Rogers (2003) defined diffusion of innovation as *"the process in which an innovation is communicated through certain channels over time among the members of a social system"* (p. 12). An innovation in its original formulation did not have to be technological, although it turned out to fit well with the technology adoption in organisational contexts (Khan & Qudrat-Ullah, 2020; Taherdoost, 2018).

Key Elements

Within DOI, four key elements of the theory can be identified: (1) the innovation itself, (2) communication channels about innovation, (3) time it takes to spread, and (4) the social system which provides the context.

The first element of the DOI is innovation. Rogers (2003) defined it as "*an idea, practice, or object that is perceived as new by an individual or another unit of adoption*" (p. 62). An important clarification made by Rogers is that innovation does not necessarily mean something absolutely new, not known to anyone. Instead, innovation knowledge differs among individuals and organisations. Within the DOI, innovation is something that appears new to the target group. Therefore, with reference to this particular study, blockchain is already an established technology in cryptocurrencies whereas its novel applications in the higher education field may not be. It will be considered an innovation then for those institutions that try to apply it for their own purposes.

The second element of the DOI theory is communication channels. According to Rogers (2003), "*the diffusion process is the information exchange through which one individual communicates a new idea to one or several others*" (p. 18). This exchange is facilitated by communication channels which could be as simple as personal interactions and as global as programs on TV. The key point here is that diffusion is a social process which is not possible without information about innovation being communicated. Rogers argues that a successful communication channel for diffusion of innovation involves a degree of *heterophily*, that is, differences between individuals in terms of certain abilities (p. 19). This, for example, can help those who do not understand an innovation fully to get new insights from those who do and can explain its benefits.

The third component of the DOI is time. Rogers (2003) argued that including time as a key dimension to the diffusion of innovation allows it to be presented as a process. This is also the main difference from the earlier theoretical frameworks of adoption. In DOI theory, there are three major dimensions of the element of time. The first step is the innovation decision process, which comprises five stages, beginning with the individual's first understanding of the invention and ending with its adoption or rejection. Next, innovativeness refers to a member's early or late adoption of innovation within the same system. The third factor is the pace of innovation, which is often evaluated by the number of members who adopt the innovation during a given time period (Rogers, 2003). These elements are discussed in more detail below.

The final element of the DOI is the social system. This is "*a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal*" (Rogers, 2003, p.37). A social system can be envisioned as an organised collective of units such as individuals, groups, organisations, or societies. Since Rogers considered innovation diffusion as taking place in social systems, he argued that the structure of such systems would be influential in the process. A structure is defined within the DOI as “the patterned arrangements of the units in a system” (Rogers, 2003, p. 24). These arrangements, along with the shared problem-solving process, influence the degree of innovativeness in a given social system. This assertion serves as a basis for distinguishing adopters within the DOI.

Diffusion Process

According to DOI, technology adoption is a process, which goes through five stages preceding the decision whether to adopt a technology (Figure 15). It starts with the assertion that *knowledge* of the technology has to be present. Those who adopt the technology should be aware of it and how it functions. The next stage is *persuasion* where information about technology becomes more reliable as it comes from peers and other technology users. At this stage, according to DOI, a decision borderline is drawn. Next comes the *decision* stage where the choice of technology use is made. Importantly, while a positive decision is formed at this stage, the technology can still be rejected at any stage of the process. In this case, further stages are automatically eliminated. In case of a positive decision regarding the technology, the *implementation* stage involves its practical applications. At this stage, the technology is further assessed in terms of usability, complexity and benefit. Finally, at the *confirmation* stage, adoption is cemented.

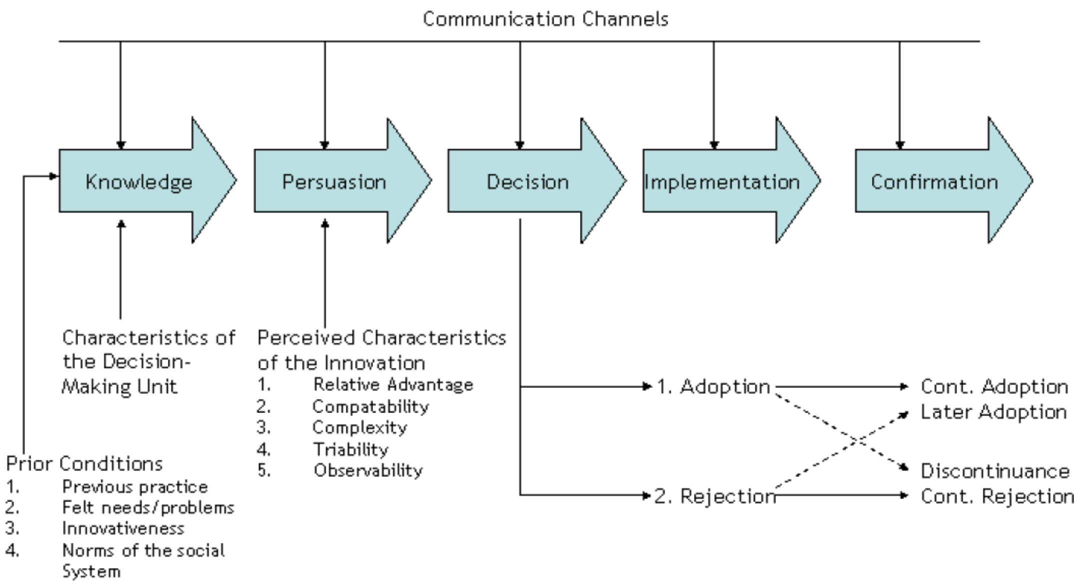


Figure 15. Innovation-Decision Process Model (Rogers, 2003)

As seen from the model, the early stages of the diffusion process contain a number of factors which, according to DOI, play an important role in moving towards the next stages of adoption. DOI distinguishes among different decision-making units in the *knowledge* stage: whether the decision will be made by individuals or organisations (Rogers, 2003). Accordingly, the adopters will have different needs, skills, and possibly experiences with technology. Further, in line with the behaviour-based theories (TRA, TPB), DOI asserts that norms existing in the social system within which the adopter operates, will also play a role.

The persuasion stage, on the other hand, contains the key innovation attributes that influence the decision about its adoption. These five elements have become the dominant technology factors in many adoption studies (Khan & Qudrat-Ullah, 2020; Tarhini, Arachchilage, Masa'deh, & Abbasi, 2015). The first attribute is *relative advantage*, which is “the degree to which an innovation is perceived as being better than the idea it supersedes” (Rogers, 2003, p. 229). Relative advantage has different expressions, and it can be seen in terms of cost, task completion or even social status (Alalyan, Jaafari, & Hussain, 2023). The second attribute is *compatibility*, which is “the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters” (Rogers, 2003, p. 15). This innovation aspect is considered important because different groups of adopters are likely to have different values and beliefs (Alalyan, Jaafari, & Hussain, 2023). The third attribute is *complexity*, which refers to “the degree to which an innovation is perceived as relatively difficult to understand and use” (Rogers, 2003, p. 15). This is a negative attribute since technologies which are difficult to learn and apply are likely to be adoptedmore slowly (Alalyan, Jaafari, & Hussain, 2023). The fourth attribute is trialability, which is “the degree to which an innovation may be experimented with on a limited basis” (Rogers, 2003, p. 16). Technologies that can be tried have a better chance of being adopted since the potential adopters are likely to see hands-on positive benefits from them (Alalyan, Jaafari, & Hussain, 2023). Finally, observability is “the degree to which the results of an innovation are visible to others” (Rogers, 2003, p. 16). This attribute refers to the degree of the innovation’s visibility and the visibility of the outcomes of its use (Alalyan, Jaafari, & Hussain, 2023). Observable innovations that produce visible positive effects are more likely to be adopted.

Innovativeness and Adopter Categories

According to Rogers (2003), diffusion of innovations is not a uniform process. This is because individuals treat uncertainty related to innovations differently: some are ready to try innovations earlier while others prefer to wait. Rogers (2003) referred this to innovativeness: “the degree to which an individual or another unit of adoption is relatively earlier in adopting innovative ideas than the other members of a system” (p. 22). Rogers (2003) proposed that in a typical society, there are several distinct groups based on their degree of innovativeness (Figure 16).

The first group to adopt a new technology is known as *innovators*. This is a relatively small proportion of adopters (2.5%) who try an innovation earlier than others. Rogers (2003) compared innovators to system gatekeepers who express a high degree of knowledge about innovations overall and who are keen to try them first. This group differs from the others by having a strong capacity to understand the core ideas behind new technologies and know how to deal with the uncertainties surrounding them. This group initially paves the way for other groups by making innovations visible.

The second group to adopt the new technology is *early adopters*. They represent about 13.5% of the adopters who are eager to try innovations early. Rogers (2003) referred to this group as change agents because it consists of influential individuals and opinion leaders who usually model adoption for the later groups. Generally, early adopters are very receptive to change and play a crucial role in the knowledge and persuasion stages of the adoption process. In fact, they "play a central role at virtually every stage of the innovation process, from initiation to implementation, particularly in deploying the resources that carry innovation forward" (Light, 1998, p. 19). With this, early adopters reduce much uncertainty about innovations and spearhead the adoption process for the majority.

The third group of adopters is *early majority*. This is one of the largest groups (34% of adopters), which consists of individuals who make adoption decisions after they observe the innovation's reputation. Unlike early adopters, who are opinion leaders, this group consists primarily of opinion followers. Accordingly, Rogers (2003) referred to this group as the deliberation group because they need the innovation to be visible and require some time to absorb the information about its benefits. As soon as this become available, the early majority group adopts the technology.

The fourth group is *late majority*. Similar to the early majority, this is a very large group consisting of 34% of adopters. Late majority comprises individuals who are generally sceptical about the innovation in question and the benefits it may produce (Rogers, 2003). Accordingly, this group adopts innovations when there is a substantial degree of information about them and/or when the costs of adoption drop to a level which is acceptable to them. Peer pressure and economic necessity may also be factors that prompt this group to adopt (Rogers, 2003).

The final group of adopters is *laggards*. This is a fairly large group consisting of 16% of innovation adopters. Rogers (2003) characterised this group as possessing the lowest amount of resources and knowledge. They may not actually need the technology that much until it becomes a standard, and this could happen even after newer innovations take place.

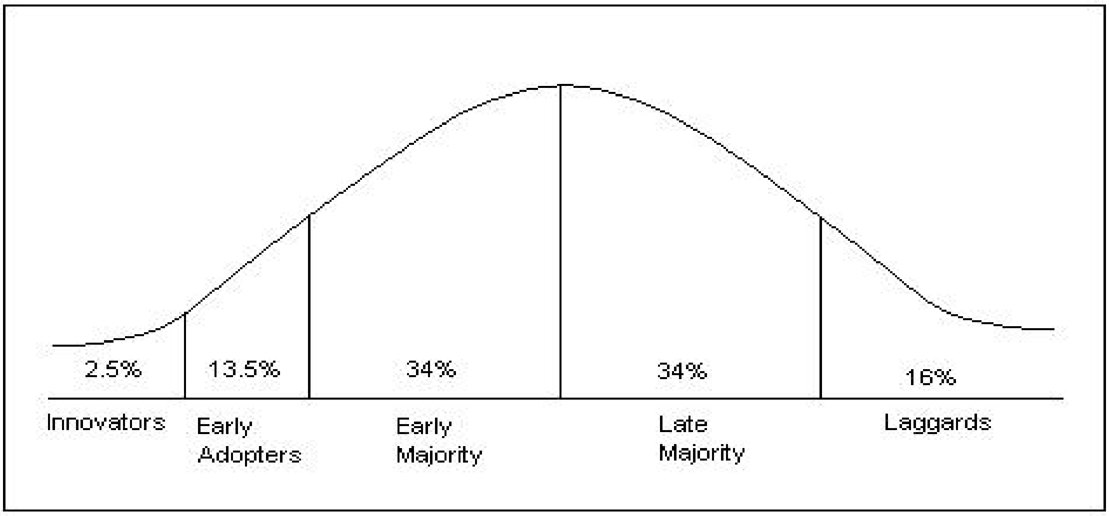


Figure 16. Innovation Adopters' Classification over Time (Rogers, 2003)

The classified types of adopters explain how and why a typical innovation becomes distributed across time. There are a few early adopters who are ready to try innovative ideas even at an increased cost and uncertainty. As the innovation spreads, it becomes increasingly visible and the results of its use are observed. This prompts an increased inflow of adopters, up until a time at which a critical mass of users is reached. After this, adoption proceeds at an increased rate and becomes self-sustaining (Tarhini, Arachchilage, Masa'deh, & Abbasi, 2015).

Theory Applications

DOI has been tested and applied in numerous studies and it remains one of the most cited technology adoption theories (Khan & Qudrat-Ullah, 2020; Taherdoost, 2018). The theory has been applied in numerous disciplines and industries to study the adoption of emerging technologies. Some recent examples include the adoption of autonomous vehicles in the transportation sector (Yuen, Cai, Qi, & Wang, 2021), the adoption of exam monitoring systems by education institutions during the COVID-19 outbreak (Raman, Vachharajani, & Nedungadi, 2021), the adoption of mobile wallets in the financial sector (Shaw, Eschenbrennen, & Brand, 2022), and the adoption of the internet-of-things in the healthcare sector (Yesmin, Carter, & Gladman, 2022) among others. Prior research has also confirmed the validity of the five technology attributes' effect in the technology adoption process (Khan & Qudrat-Ullah, 2020; Lai, 2017; Tarhini, Arachchilage, Masa'deh, & Abbasi, 2015).

The aforementioned findings make DOI a suitable theoretical framework for this research. As a strong organisational-level theory which is often used to study the adoption of emergent technologies, DOI is an appropriate theoretical choice to study the adoption of blockchain (an emergent technology) in higher education institutions (organisational level). In fact, several studies have used DOI, either as a standalone theory or in combination with other theories and frameworks, to study blockchain adoption in various settings. The technology attributes within DOI, for example, were investigated as antecedents of blockchain adoption in the freight industry (Orji, Kusi-Sarpong, Huang, & Vazquez-Brust, 2020), sustainable supply chains (Kouhizadeh, Saberi, & Sarkis, 2021), insurance (Kar & Navin, 2021) and smart learning environments (Ullah, Al-Rahmi, Alzahrani, Alfarraj, & Alblehai, 2020). Therefore, DOI has already established certain ground in blockchain adoption studies across a number of disciplines and industries. This provides another reason to use it as a theoretical foundation for this research.

Limitations

Like any other theory of adoption, DOI is not without its own limitations. One of the main criticisms of the theory is that it treats diffusion as a discrete package that takes place in fixed, homogenous social environments (Lyytinen & Damsgaard, 2001). Technological systems, especially complex systems, are usually interpreted and valued differently across time and place (Khan & Qudrat-Ullah, 2020). Accordingly, local traditions and norms, infrastructures, and socio-political and economic realities may account for differences in technology adoption. This may be especially true for organisations which are more susceptible to environmental arrangements than individual users. Therefore, researchers proposed that analyses of technology diffusion and adoption should dynamically draw from both environmental and institutional forces (Robertson, Swan, & Newell, 1996; Wolfe, 1994). DOI pays less attention to these forces than to the attributes of the technology itself.

Another line of DOI criticism is that, being primarily a communication theory, it treats adoption choices as largely outcomes of the available information, the adopter’s preferences and properties (Lyytinen & Damsgaard, 2001). Instead, the critics argue, adoption choice parameters could be far more diverse. For example, in the case of organisations, additional factors could be the chosen business strategy (does the innovation support it?), management support and overall readiness for the innovation in question (Clohessy & Acton, 2019; Khan & Qudrat-Ullah, 2020). A complex interplay of these factors is, for example, described in the Business Ecosystem Model which changes and evolves through the constant interaction of its economically linked constituents (Moore J. F., 2006). These processes and dynamics then should not be ignored in defining and scoping the innovation diffusion process (Lyytinen & Damsgaard, 2001).

Finally, as a generalised theory, DOI treats the technology diffusion process as set within fixed stages, relatively short time scales and it mostly ignores the effect of previous decision-making processes (Lyytinen & Damsgaard, 2001). Accordingly, the mechanism of innovation diffusion which drives adoption is treated as linear, fast and more or less mandatory. In other words, the theory ignores possible feedback from the system and considers both organisational and technology characteristics to be stable over time (Khan & Qudrat-Ullah, 2020). However, this may not be the case, and the role of process aspects, histories, and organisational evolution should be recognised (Ardis & Marcolin, 2017).

To sum up, DOI as a standalone theory cannot account for the complexities of the adoption process from the perspective of an organisation. While emphasising the role of technology characteristics, it does not account for intra-organisational and environmental factors sufficiently well. Further, it is often criticised for its linear nature and the absence of feedback which could influence the adoption process. In order to address these limitations, this study integrates DOI with the Technology-Organisation-Environment (TOE) framework (Tornatzky & Fleischer, 1990). In doing so, the study aims to provide a solid theoretical foundation for the research and develop a framework which is both comprehensive and flexible.

4.3.2.7 Technology – Organisation- Environment Framework

Technology-Organisation-Environment (TOE) is a theoretical framework developed specifically for studying the adoption and implementation of technology innovations by organisations (Baker, 2012). The model was presented in Tornatzky and Klein's (1990) book *Processes of Technological Innovations* which offered a comprehensive review of innovation adoption by firms. The book focused on the influence of context in which firms operate on the process of technology adoption. More specifically, TOE proposes that three such contexts play a role in a firm's adoption of technologies: technology context, organisational context and environmental context Figure 17. Each of these contexts and their roles in technology adoption are described in detail below.

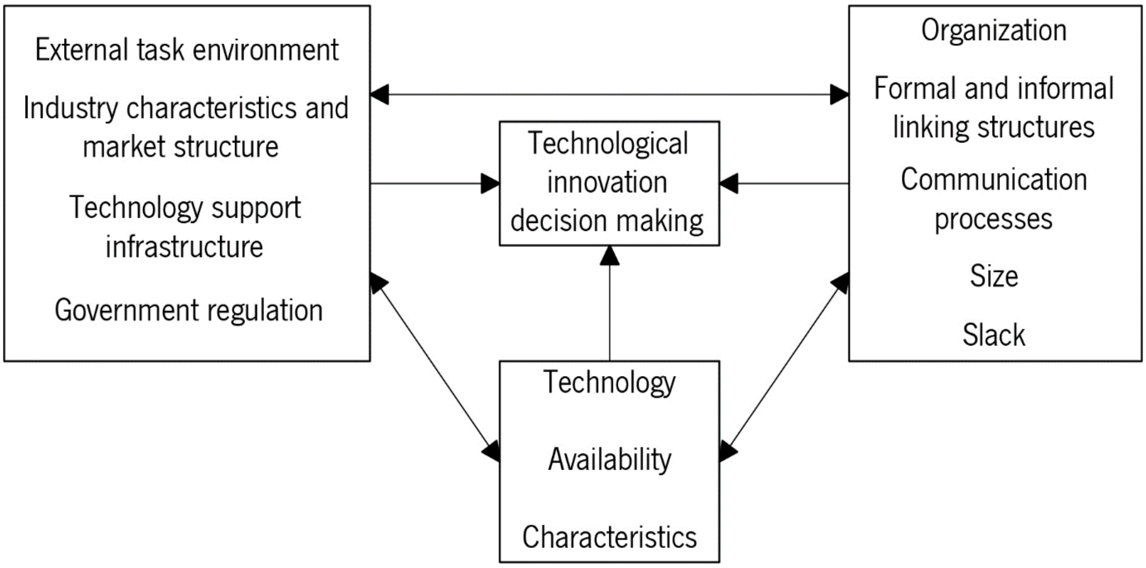


Figure 17: TOE framework (Tornatzky et al., 1990, p.154)

<u>The Technology Context</u>

The technology context within TOE includes technologies which are both in use and available in the market which could be relevant to the organisation (Clohessy et al., 2020). Two technology types are relevant for new technology adoption: the technologies used by the organisation define the scope and limit of the changes that it could apply whereas not used but available technologies define what is possible to achieve (Tornatzky et al., 1990). Tornatzky and Klein (1990) distinguished three types of innovations that define the adoption process based on the amount of risk they produce for organisations. First, incremental change technologies either update the existing technologies or introduce additional features to them. According to Baker (2012), incremental change technologies pose the least risk to organisations because of their gradual nature and lack of a groundbreaking effect on one or more aspects of organisational operations. An example of such innovation is a shift towards LCD monitors in PCs: the shift occurred over time and did not require immediate changes to operations. Second, synthetic change technologies combine the existing technologies in some new ways. According to Tornatzky and Klein (1990), these technologies pose a moderate amount of risk for organisations because the effect of such combinations usually takes time. An example of such innovation is online courseware, which combined the existing product (education) with the internet to offer a new approach to providing education services. Finally, discontinuous innovations represent radically new ideas and innovations that change the way things are done (Baker, 2012). These changes are of the highest risk for organisations because they represent fundamental shifts that lead to new technology standards and the displacement of legacy technology systems. Blockchain is an example of such innovation because it provides a completely new approach to managing digital data.

The point of distinguishing technologies by type of risk, according to Tornatzky et al. (1990), is in predicting the patterns of adoption. Specifically, for incremental change technologies, a measured pace of adoption could be acceptable (Baker, 2012). The synthetic change technologies require faster decision-making, although it could still be possible to postpone adoption for better clarity with regard to its functions and benefits. Finally, the discontinuous change technologies require fast and decisive decisions if organisations want to remain competitive (Baker, 2012). This is especially true with “competence-destroying” (Tushman & Nadler, 1986) technology solutions as they render many existing systems obsolete. Therefore, according to TOE, organisations must keep an eye on innovations and analyse the type of change expected from a technology considered for adoption.

The TOE framework originally includes technology availability and characteristics as the key factors in this dimension (Tornatzky et al., 1990). However, additional factors have been successfully integrated and tested. The five technology attributes from DOI are commonly considered within TOE (Clohessy & Acton, 2019; Lustenberger, Malešević, & Spychiger, 2021). Other frequently explored technology context factors are privacy and security, perceived benefits and technology maturity (Kouhizadeh, Saberi, & Sarkis, 2021; Reddick, Cid, & Ganapati, 2019; Wamba, Queiroz, & Trinchera, 2020).

<u>The Organisational Context</u>

The organisational context involves a firm’s resources and characteristics that could influence the adoption process (Baker, 2012). Tornatzky and Fleischer (1990) proposed several mechanisms through which such influence is recognised. First, there are internal individuals and groups that promote innovations, examples being innovation champions, opinion leaders and technology gatekeepers. Second, innovations can be promoted by cross-functional teams that have connections to organisational departments and partners. Third, organisational structures that are more decentralised and team-oriented are more supportive of innovations. Further, communication processes can either promote or impede the innovation adoption process (Tornatzky & Fleischer, 1990). Within TOE, top management plays a crucial role in this by either communicating support and linking innovation to their organisation's mission and vision or formally communicating why the innovation does not fit with the organisational strategy.

The impact of the two remaining factors within the original TOE, slack and organisational size, is much less certain in relation to technology adoption. While organisational slack has been cited as supporting innovations in some classical organisational works (March & Simon, 1958) and even within DOI (Rogers, 1995), the presence of this factor is not indicative of adoption. Tornatzky and Fleischer (1990) acknowledged that it is "neither necessary nor sufficient for innovation to occur" (p. 161). Similarly, while larger organisational size has been traditionally associated as better suited to adopt innovations, later studies painted a rather mixed picture on this (Baker, 2012; Clohessy & Acton, 2019). It was, therefore, argued that size serves as a very crude approximation of more specific resources required to stimulate adoption (Baker, 2012). In view of the uncertainties surrounding these two factors, later research introduced additional organisational variables such as, for example, organisational readiness and innovativeness (Guo & Liang, 2016; Morabito, 2017; Pilkington, 2016; Woodside, Augustine, & Giberson, 2017).

<u>The Environmental Context</u>

The environmental context represents the ecosystem within which the organisation operates: the environment with which it interacts but has little to no power to influence. Lippert and Govindarajulu (2006) described this context as a "*setting in which the firm conducts business, and is influenced by the industry itself, its competitors, the firm's ability to access resources supplied by others, and interactions with the government*" (p. 149). According to Tornatzky and Fleischer (1990), the environmental mechanisms have a number of mechanisms that influence innovation adoption. It is proposed, for example, that more intense competition stimulates novel technology adoption to gain a competitive advantage. Likewise, dominant partner firms may stimulate organisations to adopt innovations to maintain business relationships and enhance cross-organisational operations. Further, according to TOE, adoptions occur faster in environments with a good supply of technologies and appropriate technology infrastructures (Baker, 2012). Finally, all firms, regardless of their adoption intent, exist and operate within legal environments created and maintained by governments. Existing regulations may either stifle innovations by imposing a high level of costs or restrictions on the technology in question or mandating adoption by making some obligatory (one example would be anti-pollution systems).

Similar to the other two dimensions within the original TOE, the environmental context has also been modified in many studies to add or remove certain variables. Government support, for example, emerged as one of the commonly included variables in the environment context (Crosby, Nachiappan Pattanayak, Verma, & Kalyanaraman, 2016; Guo & Liang, 2016; Tapscott & Tapscott, 2016). Clohessy et al. (2020) identified other variables that were tested to a lesser extent: business use cases, critical user mass, democratisation and political stability.

To sum up, the three contexts introduced within TOE represent influential dimensions for adoption decisions at the organisational level. As shown, the dimensions include factors that could either stimulate or impede technology adoption by firms. Importantly, TOE does not constrain these dimensions in terms of the factors included. This has given researchers a good opportunity to explore additional contextual factors of adoption within each type of environment. Such flexibility is beneficial for the current study where new contextual factors are likely to emerge.

Framework Applications

Like DOI, TOE is one of the most commonly used frameworks in adoption research at the organisational level (Clohessy, Treiblmaier, Acton, & Rogers, 2020; Lustenberger, Malešević, & Spychiger, 2021). The framework is valued for its comprehensiveness and ease of expansion/modification (Clohessy & Acton, 2019; Clohessy, Treiblmaier, Acton, & Rogers, 2020). Zhu and Kraemer (2005) noted that TOE offers researchers much freedom in adding or eliminating factors that they would consider relevant, which also means that there is little need to modify the underlying theory. Baker (2012) also wrote that TOE blends well with similar theories like DOI which makes it possible to integrate them instead of offering competing views on the adoption process. Finally, TOE is considered well fit for studying the adoption of new and emerging technologies (Clohessy, Treiblmaier, Acton, & Rogers, 2020; Oliveira & Martins, 2011).

Recently, there has been an explosive growth of papers using TOE-related factors to study blockchain adoption in various industries. A review by Clohessy et al. (2019) identified 16 studies of such kind, while a year later, Clohessy et al. (2020) identified 31, thereby indicating a growth of almost 100%. Further, the TOE framework itself has become rather popular in studying blockchain adoption (Chittipaka, Kumar, & Sivarajah, 2022; Kamarulzaman, et al., 2021; Kulkarni & Patil, 2020; Schmitt, Mladenow, Strauss, & Schaffhauser-Linzatti, 2019). Still, there are very few works that applied TOE to study blockchain adoption in higher education (Barnes & Xiao, 2019; Clohessy & Acton, 2019; Janssen, Weerakkody, Ismagilova, Sivarajah, & Irani, 2020). Therefore, there is a need for more testing of the framework and checking its applicability in different higher education contexts.

4.3.2.8 Enhanced DOI-TOE Framework Choice

This study uses an enhanced DOI-TOE framework as the theoretical basis for research. The choice of such a framework is justified for a number of reasons. First, such a framework clarifies the adoption of innovative technology in higher education institutions (HEI) at the organisational level. As the review of the various adoption models and theories shows, TRA, TPB TAM, TTF, SCT, TAM and its variations focus primarily on adoption at an individual level. Indeed, studies of blockchain adoption using these theories explored the importance of individual user factors such as attitudes, comfort levels, performance expectancy, and personal perceptions of blockchain (Alaklabi & Kang, 2021; Kamble, Gunasekaran, & Arha, 2018; Queiroz & Wamba, 2019; Wong, Tan, Lee, Ooi, & Sohal, 2020). While such factors are important in understanding how blockchain adoption diffuses in societies, they explain little with regard to the elements within and outside organisations that aim to introduce blockchain for their business purposes.

In contrast, both DOI and TOE are organisational-level frameworks, as previously discussed. Both theories represent solid research frameworks applied for the adoption of various innovations across numerous disciplines and industries. Importantly, DOI and

TOE are easily integrated because they represent complementing rather than competing frameworks of adoption (Clohessy, Treiblmaier, Acton, & Rogers, 2020; Hiran & Henten, 2020). The need for such integration comes from the inability of either of the frameworks to fully account for all possible factors influencing technology adoption in organisations. DOI has a strong focus on the technological attributes of innovations, but it is less powerful in explaining the impact of organisational and environmental factors. On the other hand, the technology dimension within TOE does not readily specify and validate the technology attributes essential for the adoption process. Therefore, a combined TOE-DOI framework offers a more comprehensive view on adoption by taking into account context and considering the inherent technology characteristics influencing its adoption.

4.4 Solutions to Research Subquestions

After the choice of the general theoretical framework as the foundation for the proposed model, the next step is to identify the specific factors that drive the adoption of blockchain in Saudi HEIs. This is done by exploring the empirical literature discussing the relevant blockchain adoption factors within the TOE and DOI theoretical lines. The common approach to each research subquestion is visualised in Figure 18.

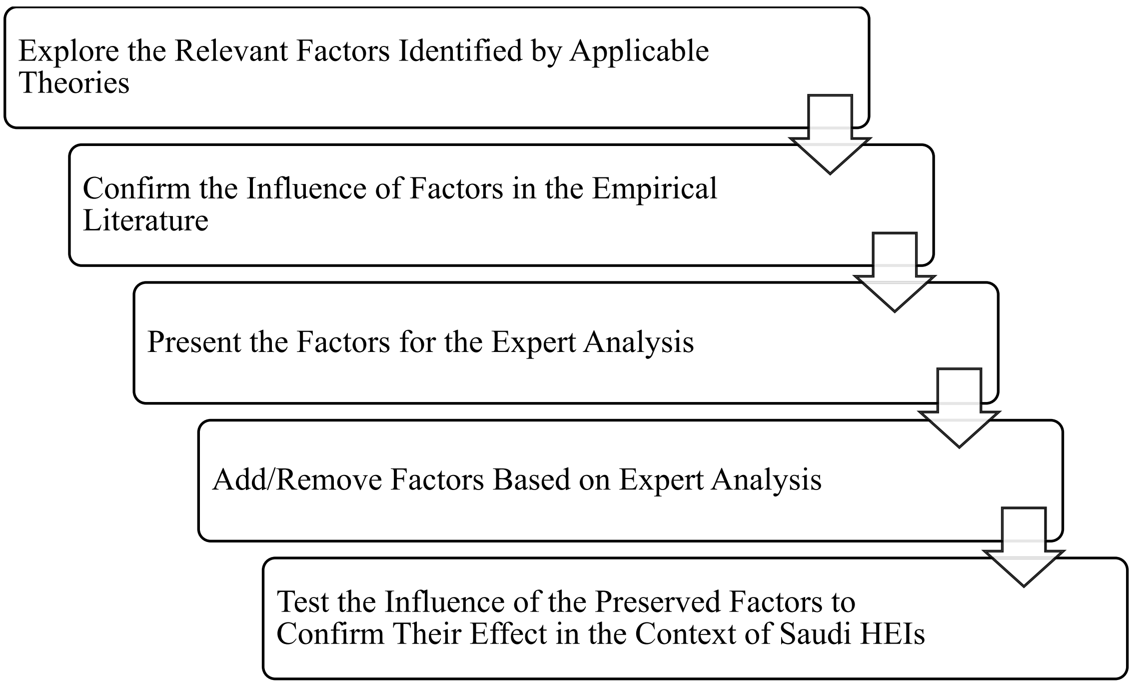


Figure 18: Approach to Research Subquestion Solutions

4.4.1 Solution to Research Subquestions 1, 2 and 3

Research subquestions 1, 2 and 3 explore the technology, organisational and environmental factors promoting blockchain adoption in HEIs. In fact, different combinations of factors within DOI and TOE have already been explored in the blockchain adoption literature. Table 17 lists the empirical studies on blockchain adoption in the educational sector that explored the influence of technological, organisational and environmental factors identified within the DOI and TOE frameworks.

Table 17: Studies of Blockchain Adoption with Factors from DOI and TOE

Study	DOI Factors Explored	Organisational Factors Explored	Environmental Factors Explored	Additional Factors Explored
Barnes & Xiao (2019)	Relative advantage Compatibility Complexity	Top management support Readiness Size Centralisation	Competition Government support Partner support Technology vendor support Customer support	Industry sector
Chen et al. (2018)	Complexity	Top management support Readiness	Government support Industry pressure Market dynamics	Perceived benefits Energy consumption
Choi et al. (2020)	Complexity Compatibility	Knowledge and expertise Collaboration Technology awareness	Government support Regulations Infrastructure	Privacy and security Costs
Crosby et al. (2016)	Relative advantage Complexity	Top management support Readiness Size Customer relationships	Government support Competition Regulations Partner's pressure	Privacy and security Perceived benefits
Duan et al. (2020)	Complexity Compatibility	Top management support Innovativeness	Competition	Perceived benefits Transparency
Guo & Liang (2016)	Relative advantage Compatibility Complexity	Top management support Readiness Knowledge	Competition Partnerships Regulations Business use cases	Security and privacy Cost Business concerns
Hartley et al. (2021)	Relative advantage Compatibility Complexity	Top management support Size	Regulations Partners' support Industry group membership	Institutional factors System update Consulting
Iansity & Lakhani (2017)	Relative advantage Complexity Trialability Compatibility	Top management support Readiness Size	Competition Partnerships Regulations Business use cases	Savings Accessibility
Kouhizadeh et al. (2021)	Complexity Compatibility	Top management support Readiness	Competition Regulations Market standards	Security Perceived benefits

		Network incentives structure		
Lustenberger et al. (2021)	Relative advantage Compatibility Complexity Trialability Observability	Top management support Readiness Size Age	Competition External pressure Regulations Collaboration Ecosystem scope	Blockchain knowledge
Malik et al. (2021)	Complexity Compatibility	Top management support Innovativeness Learning capability	Competition Government support Partners' readiness Standardisation	Perceived risks Perceived benefits
Morabito (2017)	Complexity Compatibility	Top management support Readiness Size Innovativeness	Regulations Government support Partner pressure Business use cases	Perceived benefits Costs
Pilkington (2016)	Complexity Compatibility	Top management support Readiness Size Innovativeness Network incentive structure	Competition	Perceived benefits Blockchain type
Toufaily et al. (2021)	Complexity	Readiness Business model alignment	Regulations Network effects Ecosystem readiness	Privacy and security Costs
Wamba et al. (2020)	Complexity	Top management support Innovativeness	Competition	Perceived benefits Transparency
Wang et al. (2016)	Complexity Compatibility	Top management support Readiness Size Responsiveness	Regulations Industry pressure Market dynamics	Security, uncertainty, maturity of technology
Woodside et al. (2017)	Complexity Compatibility	Readiness Innovativeness	Regulations Market dynamics	Security Perceived benefits Costs
Zheng et al. (2018)	Complexity	Top management support Readiness Size Innovativeness	Regulations Market standards Business use cases	Security Perceived benefits

Based on the review of the theoretical and empirical literature, the following factors were included in the model:

- Technology Factors: relative advantage, observability, compatibility, complexity and trialability;

- Organisational Factors: top management support, organisational size, organisational readiness;

- Environmental Factors: regulations, government support, peer pressure.

4.4.2 Solution to Research Subquestion 4

While DOI and TOE offer a rather comprehensive view on adoption at the organisational level, neither of the theories considers an important aspect of higher education, which is quality. Quality refers to *"the excellence, standards, perfection, conformance to requirements, fitness for purposes and value for money of the educational technology services level and higher education institutions outcomes"* (Harvey & Knight, 1996, p. 13). Higher institutions can adopt ICT when acquiring a relative advantage. Universities and colleges in developing countries, such as Saudi Arabia, can improve their educational quality by adopting the latest technology, such as blockchain technology (Duan, Zhang, Gong, Brown, & Li, 2020; Farah, Vozniuk, Rodriguez-Triana, & Gillet, 2018; Xu, et al., 2017). Adopting blockchain technology, increasing data security, and privacy-enhancing trust, reducing costs and improving efficiency and immutability, adopting a ubiquitous global database, and incorporating formative evaluation are highly beneficial to improving education mechanisms (Alammary, Alhazmi, Almasri, & Gillani, 2019; Kolvenbach, Ruland, Grather, & Prinz, 2018).

Higher education quality can be improved by incorporating a variety of approaches, such as quality assurance and quality enhancement, as identified by Lomas (2004). Quality assurance pertains to measures taken to avoid producing subpar products, while quality enhancement endeavors to enhance the level of students' education. In the realm of higher education, the impact of quality outcomes is extremely important as the education of every nation has a bearing on its economy and the global economy at large. In most cases, there is a direct relationship between higher education outcomes and social and economic development (Harman & Meek, 2000).

Table 18 presents five factors that define quality as drawn from the relevant research on quality in higher education (Al-Ramahi & Odeh, 2020). The first factor is excellence in ICT services which refers to exceeding the minimal required service standards in higher education. The second factor is ICT perfection which refers to minimising process limitations such as, for example, delayed response time, service downtime, and others. The third factor is value for money, which is defined as the level of return on technology investment. In the context of higher education institutions, this usually refers to improvements in service quality and operational efficiencies. The fourth factor is fitness for purpose, which essentially means that ICT has to fit the prescribed goals and objectives in education quality improvements. The final factor is higher education institution outcomes, which means improvements in university outcomes for the institution itself and its stakeholders.

Table 18. Indicators of Quality in Higher Education

Quality Indicator	Definition	Key Concepts
Excellence	High achievement standard (Harvey & Stensaker, 2008)	Exclusivity, exceeding expectations, achieving more than required
Perfection	Minimisation of process limitations (Harvey, 2007)	Zero defects, doing right from the first time, culture of quality.
Value for Money	Returns on technology investment (Harvey & Knight, 1996)	Service quality improvement, process efficiencies, accountability
Fitness for Purpose	Ability to accomplish goals and objectives (Harvey & Green, 1993)	Meeting specifications, fitting organisational mission, goals, objectives
Higher education institution outcomes	Ensuring positive technology effects for the institutions and their stakeholders (Harvey, 2006)	Enhancing processes, empowering students, spurring innovations, meeting labour market demands

Including the contribution of blockchain to quality improvements in this research is justified in several ways. Higher education institutions are keen to improve the quality of their services since this is usually a point of differentiation and a competitive advantage (Ham & Hayduk, 2003; Tsinidou, Gerogiannis, & Fitsilis, 2010; Waller, Lemoine, Mense, & Richardson, 2019). Innovative technology, in turn, is often seen as a way to enhance service quality in higher education (Danjum & Rasli, 2012; Pavel, Fruth, & Neacsu, 2015). Empirical research, for example, shows that the adoption of relatively recent technologies like cloud computing, mobile learning, and virtual reality have substantially advanced higher education service outcomes (Crompton & Burke, 2018; Qasem, Abdullah, Jusoh, Atan, & Asadi, 2019; Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020). There is also growing evidence that blockchain adoption has brought service improvements in healthcare, supply chains, and other sectors (Loizou, Karastoyanova, & Schizas, 2019; Tandon, Dhir, Najmul Islam, & Mäntymäki, 2020; Tijan, Aksentievic, Ivanic, & Jardas, 2019). Finally, this study suggests one of the reasons to add quality as a factor is the high unemployment level in Saudi Arabia, which can be directly linked with the education quality of its universities and colleges.

Therefore, the following factors are included in the quality dimension: reduction in graduates' unemployment, education service improvements and HEI administration improvements.

4.4.3 Solution to Research Subquestion 5

Neither DOI nor TOE distinguish barriers to adoption as a separate category of factors. However, the successful adoption of blockchain in Saudi HEIs will certainly require identifying such barriers so that they can be successfully addressed and overcome. Granted, certain barriers to adoption are presented in both DOI (technology complexity) and TOE (regulations). However, they remain predominantly oriented towards enablers and consider barriers to adoption among them, not separately. Choi et al. (2020) argued that this is a serious omission, especially when it comes to applying these frameworks to study uncertain technologies like blockchain.

Given the fact that, unlike some other industries, higher education is relatively slow in the adoption of blockchain (Alammary, Alhazmi, Almasri, & Gillani, 2019; Ullah, Al-Rahmi, Alzahrani, Alfarraj, & Alblehai, 2020), it is logical to assume that there are inherent hurdles that prevent the diffusion of this technology. Therefore, for practitioners, introducing a separate category of factors that impede blockchain adoption in Saudi HEI could be of great importance. Moreover, barriers to blockchain adoption in education have been well explored in literature. As shown in Section 2.6, researchers have identified at least 8 technological, 7 organisational and 5 environmental barriers to blockchain adoption in higher education. Moreover, additional barriers could be present in the context of Saudi HEIs which need to be further explored. For these reasons, this study integrated a separate barriers dimension into the DOI-TOE framework.

Based on the literature review, the following factors are included in the barriers dimension: lack of knowledge, privacy and security concerns, risk avoidance, lack of infrastructure, lack of finance, lack of specialists, lack of technology visibility.

4.5 Methodology for the Solution Test and Evaluation

After the model is finalised, it has to be tested. Specifically, the factors included in the model have to be validated and their relationships to blockchain adoption have to be confirmed. A set of specific procedures used to test the relationships within a framework is known as a research methodology (Creswell & Creswell, 2017; Wiles, Bengry-Howell, Crow, & Nind, 2013). The choice of methodology guides the way for specific methods and approaches to data collection and analysis, which are necessary to validate the model (Bryman, 2016). Saunders et al. (2019) visualised research methodology within a "research onion" with a series of layers leading from broader design choices such as a paradigmatic or philosophical basis to more specific methods for data collection and analysis (Figure 19).

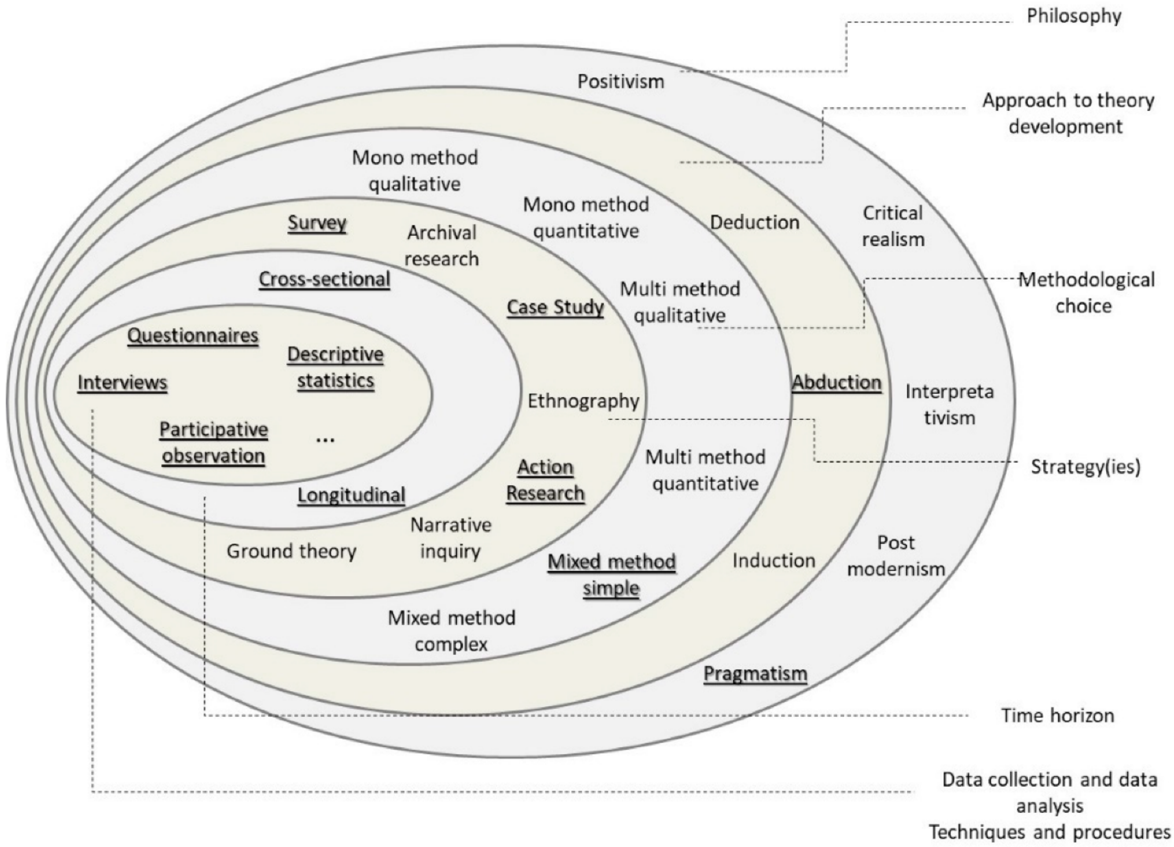


Figure 19: The 'Research Onion' (Saunders et al., 2019, p. 108)

4.5.1 Methodological Choice

Two major methodological strands are recognised in the literature: qualitative and quantitative. Qualitative research is often rooted in interpretivist philosophy inductive reasoning (Creswell J. W., 2014). Researchers who choose qualitative methodologies often seek to submerge themselves in specific contexts and gain a deep understanding of the study phenomena (Neuman, 2006; Olfazoglu, 2017). Data collection and analyses are oriented towards the development of meanings and perspectives with a strong focus on the study participants. This allows what is being studied to be described thoroughly and comprehensively. There are a number of methodological choices for this, the major six being phenomenology, ethnography, grounded theory, action research, case study and narrative research (Creswell and Creswell, 2017). Despite the richness and quality of the collected data and the flexibility of its interpretation, qualitative methods are criticised for their subjectivity, researcher bias, and difficulty in generalising the results (Olfazoglu, 2017; Taylor & Trumbull, 2005). Quantitative research usually arises from the positivist worldview and it uses deductive reasoning as the main approach to theory building (Bryman, 2016; Creswell and Creswell, 2017). Quantitative approaches apply numerical methods to study and explain particular phenomena. The emphasis is on the objectivity of the data collection and analysis techniques, high levels of data reliability and validity and large sampling sizes which enable the results to be generalised. Some common quantitative methods in research include experiments, quasi-experiments, surveys and correlational studies (Creswell and Creswell, 2017; Taylor and Trumbull, 2005). Quantitative methodologies are praised for their high level of precision, relative ease of replication and straightforwardness in the explanation of the findings. The main criticisms of quantitative methodologies relate to an excessive focus on numbers at the expense of broader themes and underlying topics, a reliance on standardised procedures that may not be fitting in specific contexts and the static presentation of the results (Bryman, 2016; Tashakkori, Johnson, & Teddlie, 2020).

This study seeks to determine the factors that influence blockchain adoption in Saudi HEIs. Currently, blockchain adoption in Saudi Arabia's higher education sector remains mostly an unexplored area. Saudi researchers have so far concentrated on the reviews of blockchain applications in higher education (e.g., Alammary et al. 2019, Alam and Benaida, 2020, Malibari, 2020) whereas empirical studies are virtually non-existent. However, blockchain adoption studies in education institutions in other countries are growing rapidly. Further, DOI and TOE are commonly established theories that are used to investigate blockchain adoption factors in the education sector (Barnes and Xiao, 2019; Clohessy et al., 2020; Janssen et al., 2020; Toufaily et al., 2021; Ullah et al., 2020). Therefore, an effective approach to meet the study purpose is to combine qualitative and quantitative methodologies to capitalise on the strengths of each. Qualitative research can help understand the topic of blockchain adoption in education applied specifically to the Saudi HEIs context and quantitative research can offer a means by which to test the established theory and relationships in this context. Therefore, a mixed methods methodology was chosen for this study.

4.5.1.1 Rationale for Use

Mixed methods research is defined as research that "combines elements of qualitative and quantitative research approaches … for the broad purposes of breadth and depth of understanding and corroboration" (Johnson, Onwuegbuzie, & Turner, 2007, p. 123). This is different from multi-method qualitative or quantitative studies where more than one method of the same methodology type is applied (Saunders et al., 2019). In this way, mixed methods research integrates the perspectives attained in both qualitative and quantitative methodologies while reducing their weaknesses. In fact, overcoming the limitations of each methodology was the reason for introducing mixed methods research in the first place (Campbell & Fiske, 1959; Webb, Campbell, Schwartz, & Sechrest, 1966).

The mixed methods methodology is being increasingly recognised today as a superior approach to research in contrast to pure qualitative or pure quantitative methods (Tashakkori et al., 2020). Creswell and Creswell (2017) argued that the mixed methods methodology enhances a researcher's understanding of the phenomena being investigated. It is also argued that a mixed methods approach can enhance the validity of the study results by combining and comparing the findings from quantitative and qualitative analyses (Tashakkori et al., 2020). Collins et al. (2007) proposed that by using a mixed methods methodology: 1) the sample size can be balanced with in-depth perspectives from the participants; 2) the validity of the data collection instruments can be improved; 3) high levels of data integrity can be attained; and 4) the study findings can be enhanced. Finally, Bryman (2016) argued that a mixed methods methodology allows both processual and static information to be effectively investigated and for different aspects of the investigated problems to be addressed.

By choosing a mixed methods methodology, this study aims to come to a detailed, comprehensive understanding of blockchain adoption in Saudi HEIs which will allow for robust theory building and testing. Mixed method studies of blockchain adoption are not as widespread as pure quantitative or qualitative studies, although there is an indication that this type of methodology is gaining attention with several recent publications (Clohessy & Acton, 2019; Delghani, Kennedy, Mashatan, Rese, & Karavidas, 2022; Gökalp, Gökalp, & Gökalp, 2020; Werner, Basalla, Schneider, Hays, & Brocke, 2021). Researchers conducting these studies criticised the lack of an integrative approach to understanding blockchain adoption in specific contexts. Further, the aforementioned papers took TOE as a theoretical basis but uncovered the context-specific factors of blockchain adoption and tested them successfully as a result. Therefore, there is good supportive ground for applying the mixed methods methodology in the analysis of blockchain adoption, as intended in this study.

4.5.1.2 Choice of Mixed Methods Design

There are several ways to construct mixed methods research considering that it combines quantitative and qualitative methods. Tashakkori et al. (2020) identified three major types of mixed methods research: concurrent, sequential and conversion. Concurrent mixed methods studies apply qualitative and quantitative methods simultaneously and compare the results. Sequential mixed methods studies begin with one methodology and then use the other one to clarify or enhance the results afterwards. Two methodologies are possible here, where either the qualitative or quantitative method takes precedence. Finally, the conversion design mixes both methodologies at every research stage as the data are transformed for qualitative and quantitative analyses. As such, four major types of the mixed methodologies are recognised, as discussed below.

In the convergent parallel mixed methods design, researchers collect and analyse data with quantitative and qualitative methods independently, at the same time (Creswell and Creswell, 2017). Both types of analysis are given equal consideration, and the results are compared to enhance the validity of the conclusions. This type of design is often used to acquire an in-depth understanding of a phenomenon being investigated (Tashakkori et al., 2020). In a sequential exploratory design, a qualitative methodology is prioritised: after the qualitative data collection and analysis, quantitative methods are used to clarify the findings or test/confirm the developed relationships (Creswell and Creswell, 2017). This methodology is suited for developing new or refining existing theories and perspectives and then testing them. In a sequential explanatory design, a quantitative methodology is prioritised: the results of the experiments or statistical tests are used as a foundation for knowledge building with the qualitative methods serving to clarify certain results (Tashakkori et al., 2020). Finally, the embedded mixed methodology assumes data collection is undertaken using both qualitative and quantitative methods, although one method serves as the dominant, larger design whereas the other plays a complimentary, supportive role (Creswell J. W., 2014). This methodology is applied to enhance the findings acquired via the dominant methodology. The four mixed methodology approaches are summarised in Table 19: Mixed Methodology Designs.

Table 19: Mixed Methodology Designs

Methodology	Sequence	Description	Application
Convergent parallel	Quant and qual done simultaneously	The methodologies are given an equal weight in investigating and explaining a phenomenon (triangulation).	Attain a thorough understanding of a research question and enhance the validity of the findings.
Exploratory sequential	Qual first, quant afterwards	Qualitative takes precedence, quantitative is used to test and confirm the findings.	Develop/revise theories or models and test them.
Explanatory sequential	Quant first, qual afterwards	Quantitative takes precedence, qualitative is used for further explanations.	Gain an understanding of the unexpected results of experiments or surveys.
Embedded	Primary and secondary methodology. Sequence depends on the research needs.	One methodology is dominant, the other serves to support/clarify research findings as it progresses.	Improve the research design, clarify the findings at each stage of the analysis.

(Adapted from: Creswell, 2017; Tashakkori et al., 2020)

This study applies the exploratory sequential design to investigate the research questions. The main goal of the study is to identify the essential factors influencing blockchain adoption in a specific context of Saudi HEIs. The context-specific approach assumes that, while a general adoption theory may be applicable, some new factors may emerge and literature-proposed factors may not be significant. To understand which factors could be important, qualitative research was undertaken first where the expert study participants offered insights about the applicability of the blockchain adoption factors identified in the relevant literature and suggested new ones. After the initial model was refined, a large-scale quantitative study was undertaken to test the relationships within the revised framework. The exploratory sequential study design is visualised in Figure 20.

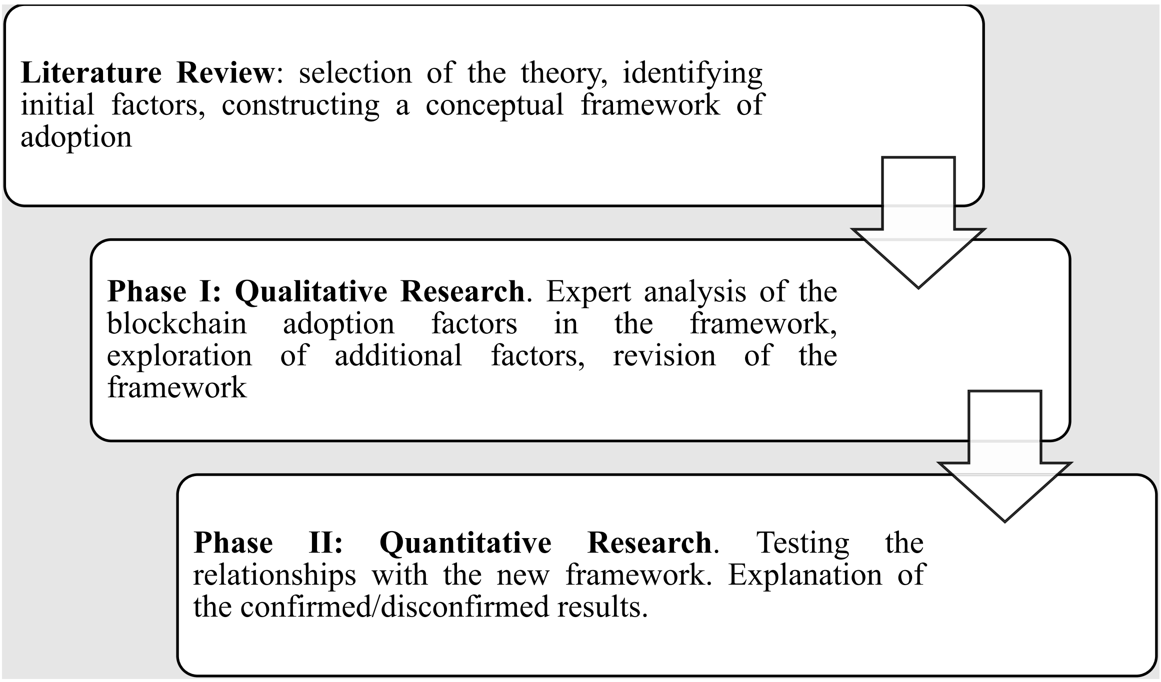


Figure 20: Exploratory Sequential Methodology of the Study

4.5.2 Research Strategy

Research strategy refers to the process applied to conduct the research (Remenyi, Williams, Money, & Swartz, 2003). Within the 'research onion', Saunders et al. (2019) identify six examples of a research strategy: survey, archival research, case study, ethnography, action research, narrative inquiry and ground theory. Other strategies are also recognised as valid; for example, experiment, quasi-experiment, phenomenology and correlational research among others (Creswell and Creswell, 2017). This study uses surveys as the primary research strategy. A survey is defined as "the collection of information from a sample of individuals through their responses to questions" (Check & Schutt, 2012, p. 160). It is used in a wide variety of applications, from academic fields to business brands exploring marketing options and consumer choices. In the academic disciplines, surveys are currently developed in a rigorous strategy with scientifically backed strategies for sampling, data collection procedures and methods to reduce bias and potential errors (Fowler, 2013; Tashakkori, Johnson, & Teddlie, 2020).

The choice of surveys as the research strategy in this study is based on several considerations. First, surveys are a popular and commonly used type of research because they are flexible in nature by allowing various sampling procedures, methods of data collection and instruments (Creswell and Creswell, 2017; Saunders et al., 2019). Second, surveys can be used in both quantitative and qualitative types of research by asking the study participants closed and open-ended questions (Brannen, 2017; Fowler, 2013). This is an important feature given the mixed methodology choice in this study. Third, surveys are well-established in the studies of human behaviour, psychology and drivers (Singleton & Straits, 2009). This makes them well suited to examine the factors driving blockchain adoption in education. Finally, surveys are notable for their reach, as they allow both small and large populations to be covered with relative ease and provide a possibility to generalise the results (Creswell & Creswell, 2017). As such, the choice of the survey strategy enables research to be conducted both within a smaller group of experts and a larger population of IT professionals and HEI administrators. It also helped to overcome the time and budget constraints of this research.

4.5.3 Time Horizon

The time horizon layer defines the timeframe within which the study is conducted (Saunders et al., 2019). The two alternative time horizons are longitudinal and cross-sectional. A longitudinal time horizon, as the name suggests, involves data collection over a long period of time with the subsequent analysis and comparison of the findings (Bryman, 2016; Creswell & Creswell, 2017). In contrast, a cross-sectional time horizon assumes data collection over a short period of time to capture the state of matters at a particular moment (Bryman, 2016; Creswell & Creswell, 2017). It attempts to match the study population closely and, therefore, involves groups of different individuals. While longitudinal research may offer more robust results and insights into how variables are changing over time, they often demand serious investments in time and resources, both human and financial, to meet the high rigour of the requirements (Bryman, 2016). Further, longitudinal studies require a high degree of control as participants tend to withdraw or change their behaviours. Finally, such studies are better suited for investigating the influence of a few significant factors over time rather than multiple factors acting simultaneously, as is the case with this study. For all the aforementioned reasons, the cross-sectional time horizon is chosen for this research.

4.5.4 Methods for Data Collection and Analysis

As previously discussed, this study follows the exploratory sequential methodology. As such, the data collection and analysis are conducted in two phases. First, qualitative research is used to clarify the research frameworks and the relationships within it. After this, quantitative research is used to test the updated framework and relationships. The methods of data collection and analyses for each are described in detail below.

4.6 Research Phase I: Model Presentation

Following an extensive literature search and analysis, this study identified a series of factors that the previously conducted research found significant in the process of blockchain adoption in HEIs. However, to make the proposed framework more fitting to the context of Saudi HEIs, qualitative research was undertaken. The purpose of qualitative data collection and analysis is to refine the model by introducing the new context-specific factors and eliminating ones that are considered insignificant.

4.6.1 Data Collection

Qualitative data collection was undertaken through a series of semi-structured interviews. This approach is applied to obtain respondents' views, opinions, thoughts and perspectives on a specific topic (Creswell & Creswell, 2017). Such interviews involve responses to open-ended questions that are organised around certain topics. Hence, they are more flexible than structured interviews, making them suitable for acquiring new perspectives on the issues while remaining within the subject narrative without deviating too much from the important topics. To fulfil these objectives, semi-structured interviews follow a specific protocol which contains subject topics/themes and associated questions (Brinkmann & Kvale, 2015). The questions, in turn, serve as guidance and may be asked in a different manner to different individuals.

The choice of semi-structured interviews for the qualitative data collection in this research was based on several factors. The interviews were conducted based on a previously developed framework and thus, can be easily organised by themes. It is important to remain within these themes to follow the theoretical lines of the research. On the other hand, a certain amount of flexibility is necessary to allow the respondents to express ideas about new factors relating to blockchain adoption. As such, semi-structured interviews are an ideal choice by using themes and allowing free expression of opinions and insights within them. Most of the weaknesses of semi-structured interviews, such as issues with generalising the findings and issues with subjectivity are resolved by testing the findings with the statistical methods in the second phase of the research.

Unlike quantitative types of research, there are no universally established norms for sampling sizes in qualitative studies. The qualitative research literature (Guest, Namey, & Chen, 2020; Fusch & Ness, 2015) and the literature specialising in qualitative interviews (Brinkmann & Kvale, 2015; Weller, et al., 2018) generally recommend a saturation approach. Data saturation is defined as a situation when additional data collection does not yield meaningful new insights required for a robust understanding of the studied phenomenon (Guest et al., 2020). Following these guidelines, this study assesses the data saturation point from the perspective of developing new themes and insights about blockchain adoption in Saudi HEIs. If no such insights are developed over the course of a given interview, the data saturation point is reached.

A minimum number of interviewees nevertheless is determined to ensure that the sample size is balanced in terms of gender, position and the type of HEI (private/public, small/medium/large). To do this, a convenience sampling approach was used. Whereas convenience sampling is not recommended in quantitative research, qualitative studies often use it for the purpose of balancing a small sample to include possible representatives of all study groups (Brinkmann & Kvale, 2015). The participants were recruited through the personal network connections of the researcher. The main requirement for inclusion in the study sample was that the participant should hold a decision-making position in a higher education institution. The final sample included 10 individuals in information technology and management jobs in Saudi colleges and universities.

The qualitative data collection took place in March 2022 using online communication tools (Zoom, Skype). Prior to the interviews, all participants were given information about the study purpose, the goals of the interview and their rights as the study participants. In line with the literature recommendations, a set of themes was developed to guide the interviews: overall views of blockchain potential for education and the respondents' HEIs, factors supporting blockchain adoption in education (grouped within technological, organisational, environmental, human, resources and quality dimensions) and barriers to adoption. The interview protocol is presented in Appendix A. The interviews were conducted in Arabic and then translated into English, and the interview times ranged from 30 to 50 minutes. Upon completion of the interviews, the participants were sent their respective transcriptions so that they could make changes if necessary to better express their thoughts and ideas. The revised transcripts were then used for the data analysis.

4.6.2 Data Analysis

The collected qualitative data were mamually analysed using content analysis, which is a common technique for analysing transcript data (Elo & Kyngäs, 2008; Guest, MacQueen, & Namey, 2012). A directed content analysis technique is used in this study because it is considered the best approach to build upon the existing theories and frameworks (Assarroudi, Heshmati, Armat, Ebadi, & Vaismoradi, 2018; Hsieh & Shannon, 2005). The goal of directed content analysis is "to validate or extend conceptually a theoretical framework or theory" (Hsieh & Shannon, 2005, p. 1281), which is the purpose of this qualitative research phase, namely seeking to refine the framework for the existing adoption factors with a strong theoretical background by adding and removing the factors emerging during the interviews.

The data analysis is based on the approach prescribed by Miles and Huberman (2019), consisting of three stages. The first step in the qualitative data analysis involves data reduction and organisation, which is followed by pattern coding and, finally, data display and interpretation. The choice of the directed content analysis approach enables data analysis to follow a more structured process than conventional approaches (Hickey & Kipping, 1996). In the data reduction stage, the transcribed data are simplified and coded. In the conventional content analysis approach, the codes are developed anew; however, a directed content study usually uses the applied theories and models to develop initial coding categories (Potter & Levine-Donnerstein, 1999). Accordingly, this study has predetermined codes arising from the variables in the proposed conceptual framework (Section 4.4 of this thesis). Whenever data cannot be readily assigned to any predetermined category, they are assigned to a new category with the potential to be developed into a novel blockchain adoption factor.

Following the data reduction and coding, patterns in the data were investigated and marked. Specifically, the frequency of mentions for each coded factor were noted. The factors that were mentioned frequently and the factors that were mentioned rarely were investigated separately. The frequently discussed factors were analysed with regard to potential influence on blockchain adoption, in terms of both direction (positive or negative) and strength (weak, moderate, strong or unclear). The factors that were discussed rarely were considered as candidates for elimination or integration with the other factors. This is known as deductive category application (Mayring, 2000). Similar patterns identified across the transcripts were used to develop the themes which would help decide regarding a factor (retain in the model, eliminate, move/integrate with others) and offer explanations for that decision.

The outcome of the qualitative analysis is the revised framework for blockchain adoption in Saudi HEIs. The process of qualitative data analysis is summarised in Figure 21.

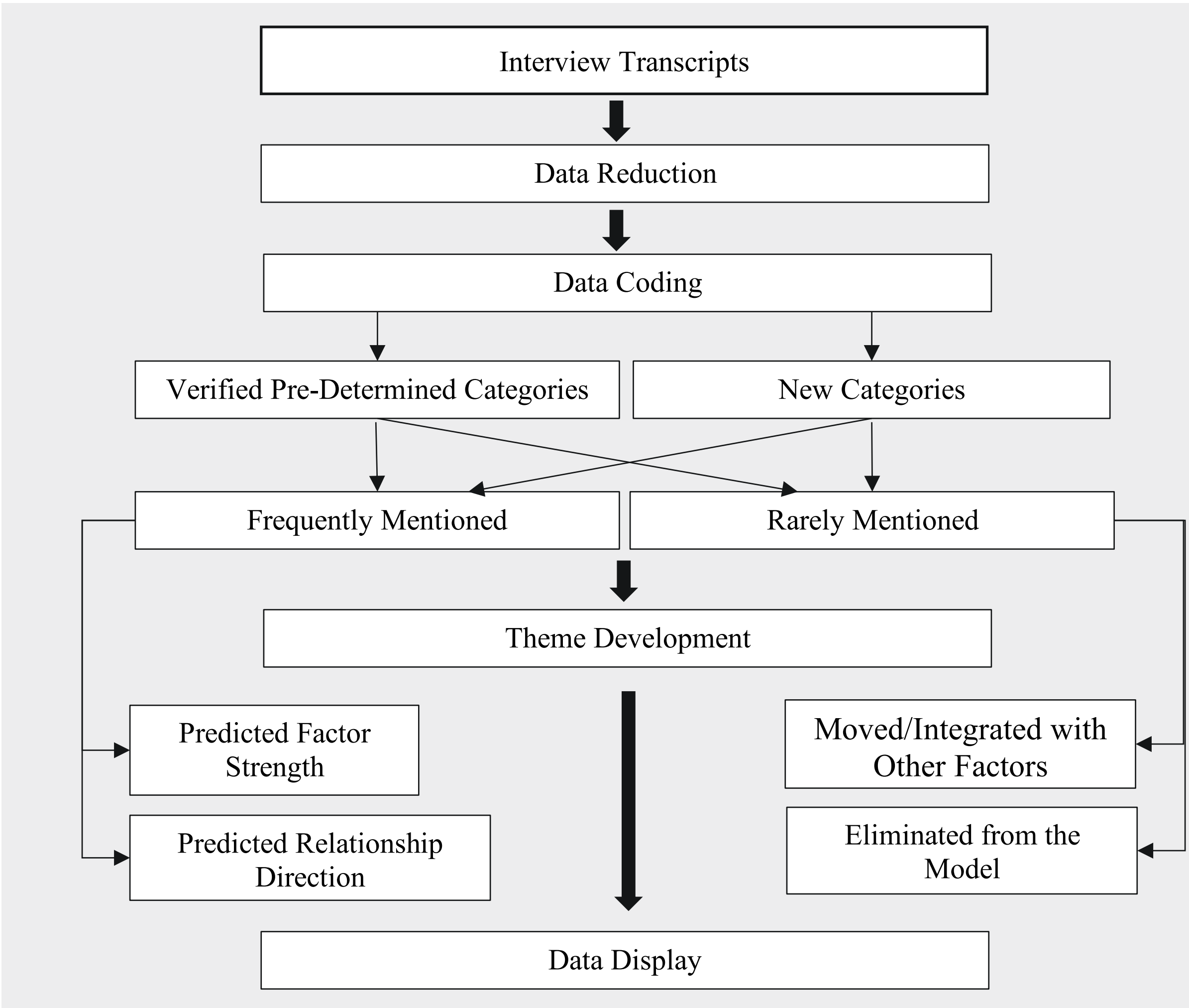


Figure 21: Qualitative Data Analysis Approach

4.7 Research Phase II: Model Evaluation

Quantitative methods allow researchers to collect and analyse large amounts of data from many subjects, thereby increasing the chance of generalising the results (Creswell J. W., 2014). Further, quantitative methods offer a higher degree of accuracy and objectivity which ensure the reliability and validity of the findings. Through the use of numeric analysis and statistical methods, quantitative studies make it possible to compare these findings with the existing studies on the subject as well as facilitate analyses across time and categories.

This study uses an online survey as the primary method of data collection. Surveys are one of the most common approaches to data collection in quantitative research (Fowler, 2013; Tashakkori, Johnson, & Teddlie, 2020). Questionnaires are usually used as the data collection tool (Creswell & Creswell, 2017). Online surveys have become common in view of the development of digital and online technologies as well as the penetration of the internet into wider society groups. The following advantages of online surveys make them the preferred method for data collection in this study (based on Creswell, 2017; Saunders et al., 2019):

1. *Structure and organisation*: surveys can be easily replicated and the results can be easily compared;

2. *Large number of participants*: it is possible to collect data from many participants to ensure a large sample size involving individuals from various backgrounds;

3. *Reducing bias*: online surveys detach the participants from the researcher thereby minimising personal biases in the research;

4. *Low cost*: online surveys are easy to set up on the existing platforms with minimal costs to the researcher. No travel is required of the researcher;

5. *Participant anonymity*: since data are collected online, no personal information is shared and participants are at ease answering questions from the comfort of their personal space;

6. *Data codification*: online surveys simplify data coding and organisation due to in-built online tools that speed up the process and minimize human errors in data entry;

7. *Data analysis:* data analysis can be easily performed using integrated quantitative tools and statistical packages for both descriptive and inferential analyses;

8. *Reducing pandemic risks*: online surveys comply with the social distancing and lockdown measures during the COVID-19 pandemic.

4.7.1 Data Collection Process

Figure 22 visualises the quantitative data collection approach used in this study. A survey questionnaire was developed as the primary tool for data collection. A survey questionnaire enables information to be gathered from a large number of IT professionals in Saudi higher education institutes. For instance, positivist researchers believe that the most appropriate research method is an extensive sample survey as it provides a specific degree of control over the collection and analysis of data using the parameters and statistical processes for the research design (Orlikowski & Baroudi, 1991). The items in the questionnaire reflect the constructs proposed in the conceptual framework of the study. A focus group comprising a small sample of Saudi school administrators was held to analyse their blockchain technology awareness. They demonstrated limited knowledge of the technology which was attributed to the fact that blockchain has only recently emerged and its practical applications in higher education are not widespread. It was decided that to ensure the respondents did not misunderstand any of the survey questions, a short description of blockchain technology would be provided on each page of the questionnaire.

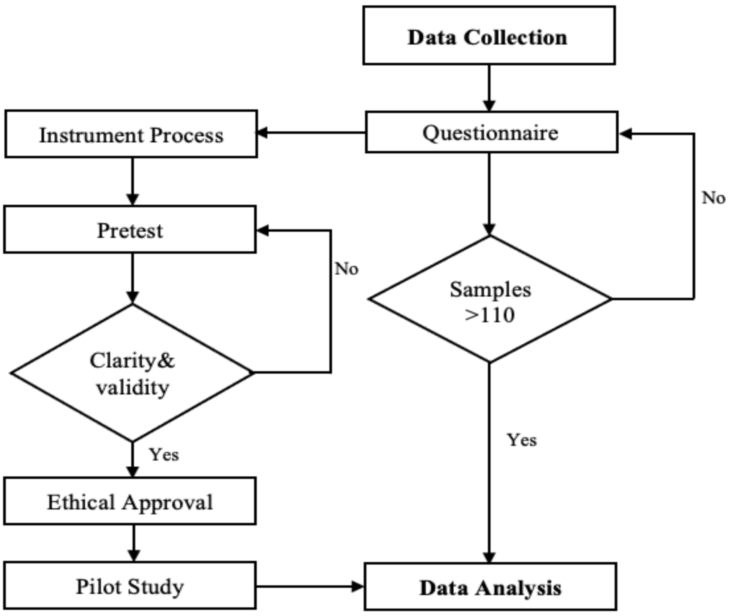


Figure 22: Quantitative Data Collection Process

4.7.2 Instrument Development Process

The questionnaire development procedure proposed by Moore & Benbasat (1991) is used in this study. According to this process, questionnaire development takes place in three stages: item creation, scale development and instrument testing.

- Stage 1: Item creation

The items for the questionnaire are developed to correspond to the constructs identified in the finalised research framework. The research framework is finalised following the completion of Phase I of the current research. Accordingly, the instrument, along with the sources of items, is presented in Section 6.5. An important consideration of the questionnaire preparation at this stage was the appropriate translation of the items. Indeed, even though a questionnaire may have been validated in the country of origin, it could only be considered robust in a different socio-cultural context if it maintains the psychometric properties in the new language (Maindal, Kayser, & Norgaard, 2016; Tsounis & Sarafis, 2018). In order to ensure a rigorous approach to questionnaire development, professional translator services were used. The study employed the forward-backward translation approach (Brislin, 1970; Jones, Lee, Phillips, Zhang, & Jaceldo, 2001). First, a bilingual native Arabic speaker translator translated the questionnaire into Arabic. Next, a different translator used the translated version to backtranslate into English without looking at the original questionnaire version. The two versions were compared to note any differences which would be corrected for the final version upon agreement from the translators.

- Stage 2: Scale development

All items corresponding to the study constructs are based on a 7-point Likert scale to maintain integrity and continuity. A 7-point scale is considered to be superior to a 5-point scale for several reasons. Nunnally (1967), for example, determined that a 7-point scale offers a better balance between the number of discriminant points and the reliability of the items. Diefanbach et al. (1993) found that a 7-point scale is better suited to reflect the subjective evaluations of respondents, such as beliefs regarding technology applications. They reported that from the participant's perspective, 7-point scales were the most accurate and easiest to use. Sierles (2003) showed that data based on a 7-point scale are more suited for advanced statistical analyses. Finally, Lewis (2003) found that 7-point

Likert scales correlated better than 5-point scales with the significance levels. Based on these assertions, a 7-point scale was chosen with the following answer options and coding: “1-strongly disagree,” “2-disagree,” “3-somewhat disagree,” “4-neither agree nor disagree,” “5-somewhat agree,” “6-agree,” and “7-strongly agree.”

- Stage 3: Instrument testing

In the last stage defined by Moore and Benbasat (1991), the questionnaire is pre-tested before being distributed to the participants. In this study, pre-testing was based on the independent evaluations of two groups. The first group consisted of IT professionals who assessed the clarity of the questions and the other group comprised PhD students who were asked to check if there were any issues related to the time needed to complete the questionnaire and how easy the survey tool was to use.

4.7.3 Population and Sample

The target population of the study is the administrative and IT staff of higher education institutions in Saudi Arabia. At the time of the study, there were 80 accredited colleges and universities in the country, 14 of which were private. While it is difficult to determine the exact number of administrative and IT specialists, a reasonable estimation based on the researcher’s information on the two universities is that there were between 800 and 1000 individuals who met the criteria for participation in the study. The study participants are individuals who held sufficiently high positions to enable them to assist in formulating an institution’s technology development strategy, such as administrative specialists (members of the boards, presidents, vice presidents, and deans) and technology specialists (IT managers, technology consultants, CTOs).

In view of its relatively small size, the study aims to cover the entire target population. Following Green (Green, 1991), the minimum number of participants is 104 + n, where n is the number of independent variables: this brings the required minimum number of participants to 115. Based on Nunnally and Bernstein (1967), the minimum number of respondents is 10*n, which is 110. A more rigorous approach is to use a statistically verified sampling size formula (Dattalo, 2008):

$$n = N * \frac{X}{X + N - 1} \qquad (1)$$

where

n is the minimum sample size;

N is population size;

and X is a measure of confidence estimated as:

$$X = \frac{z^2 * p * (1 - p)}{\varepsilon^2} \quad (2)$$

z is a z-score;

p is standard deviation;

ε is the desired margin of error.

Using the formulas above, a sample of 115 participants from a population of 1000 has a margin of error rate at 8.60%. To reach a rigorous 5% margin of error given the population size, at least 278 responses are needed. Therefore, the study aims to collect at least 278 responses for the maximum size effect, although anything above 110 participants is deemed acceptable.

4.7.4 Data Collection Process

The pre-tested, finalised, and ethics-approved questionnaire was placed online on the Qualtrics survey tool which supports both the English and Arabic languages. To obtain permission to reach the target population, letters of request were emailed to the college and university administrators in Saudi Arabia. Their email addresses were obtained from the institutions' websites. The email contained the following: 1) a cover letter briefly explaining the research and asking for assistance in recruiting study participants; 2) the researchers' requisites for further communication; 3) an attached approval form from the UTS ethics committee. If a positive response was received, the administration was given the survey link to be distributed among the potential study participants. If the administration did not respond, a second request email was sent three days after the first. If an institution declined to participate, no further action was taken.

4.7.5 Data Analysis

Figure 23 illustrates the quantitative data analysis process applied in this study. The data analysis for the study is conducted with SPSS 22.0 and AMOS. The first part of the analysis presents the sample description based on the answers from the General Information section. The inferential analysis is conducted in two steps. First, a measurement model is estimated for validity using confirmatory factor analysis (CFA) (Thompson, 2004). The measurement model is used to test the validity and reliability of the collected data. The internal consistency is tested with the Cronbach's alpha at a 0.05 level of significance (Connelly, 2011). Discriminant validity analysis is performed using square root average variance extracted (AVE) (Fornell & Larcker, 1981). Finally, a common method bias test is performed using Harman's single factor analysis (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

In the second step, the structural model is specified to examine the cause-and-effect relationships between the study variables. The model's fit is tested using a number of parameters: the comparative fit index (CFI), root mean square error of approximation (RMSEA), root mean square residual (SRMR), and Tucker–Lewis Index (TLI). Following Kline (2015), the required CFI and TLI level is established as 0.9 or higher, while both RMSEA and SRMR are set at 0.1 or lower. Additionally, scales were adjusted and items were removed to achieve a good model fit if necessary.

The hypotheses were analysed through path analysis using the finalised structural model. All tests were performed at a 0.05 level of significance.

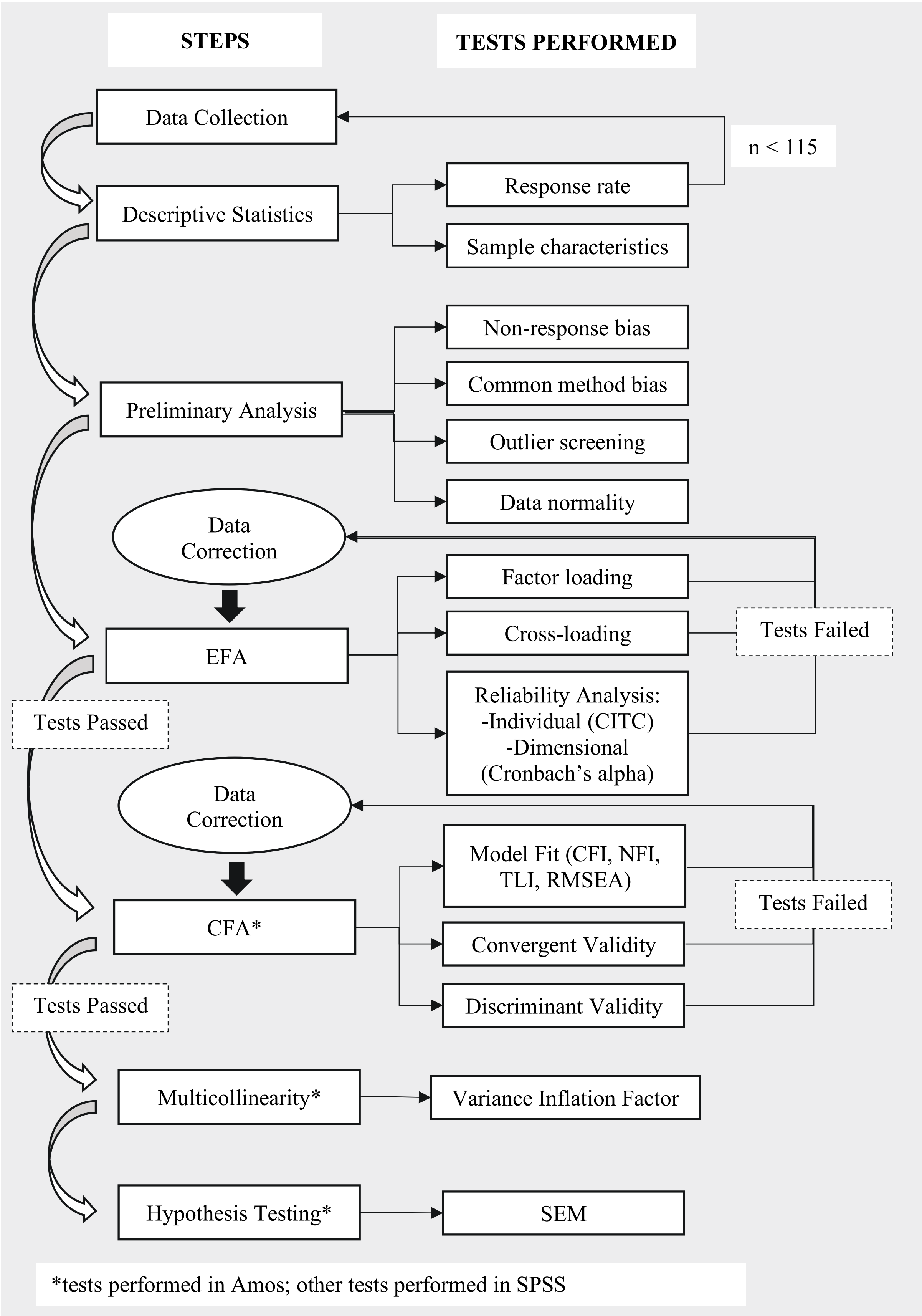


Figure 23: Quantitative Data Analysis

4.8 Ethical Approval

Before carrying out the research activities, the relevant ethics forms were submitted by the researcher to the UTS Human Research Ethics Committee at UTS for approval. The participants were also informed by the researcher that at all stages of the research, the code of ethics of UTS would be adhered to. The researcher also sent a formal request to the Saudi Ministry of Education to carry out the research. Written information regarding the aims and objectives of the study was given to all the participants based on language preferences: in English or in Arabic (Appendix B). It was clearly stated in the consent form that participation in this study is voluntary and that participation can be withdrawn at any time. The consent form was available in either English or Arabic (Appendix C). The process of data collection took place in a highly confidential manner and the participants' identities were kept anonymous. The data were only utilized for the purpose of this research and the findings were limited to academic publications only.

4.9 Chapter Summary

This chapter described the solution proposed to address the research questions and the chosen methodology. Following the science design approach, the chapter outlined a six-step process for developing the solution and addressing the major research question and the associated subquestions. The solution starts with a review of theories that could form the foundation for the model of blockchain adoption. Due to the focus of the study on organisations and an intent to introduce additional contextual variables, DOI (Rogers, 1995) and TOE (Tornatzky & Fleishcer, 1990) were selected to form the theoretical foundation. These are comprehensive, validated organisation-level theories that also offer due flexibility allowing the addition or removal of contextual variables. These were supplemented with a quality dimension (Harvey, 2007) and barriers to adoption (Clohessy, Treiblmaier, Acton, & Rogers, 2020).

To test and validate the proposed model, a mixed research methodology was selected and justified. In Phase I of the model validation, it is presented to a group of industry professionals for the initial valuation through an interview process. The final product is the refined model with some original factors removed or added. In Phase II of the model validation, a large-scale survey is conducted to determine the efficacy of the model in predicting blockchain adoption in Saudi HEIs. This chapter described the methods of data collection and analysis for both research phases.

The next chapter describes the proposed model and the relationships among its variables.

5 The Model of Blockchain Adoption by Saudi HEIs

5.1 Introduction

This chapter presents and describes the initial model of blockchain adoption by Saudi HEIs. The model was developed after a thorough review of the theoretical and empirical literature on blockchain adoption. Section 5.2 visualises the model which is a three-dimensional DOI-TOE framework supplemented with education quality context and a separate barriers dimension for practical purpose. Sections 5.2.1-5.2.5 operationalise and describe the role of each model dimension in the following order: technology, organisation, environment, quality and barriers. For each dimension, an explanation of the hypothetical role of each factor in the blockchain adoption process is given.

5.2 Research Model

Taking the enhanced DOI-TOE framework as a basis, this study proposes that the adoption of blockchain in Saudi HEIs is a function of five dimensions: technology context, organisational context, environmental context, quality context and barriers to adoption. The original framework is presented in Figure 24. The proposed framework identified 21 factor relationships. The inclusion of the potential adoption factors in each dimension was based on the review and analysis of the empirical literature and the key postulates within DOI and TOE theories applied to blockchain technology (Chapters 2 and 4). Accordingly, the operationalisation and effect of each construct on blockchain adoption in Saudi HEIs is discussed below.

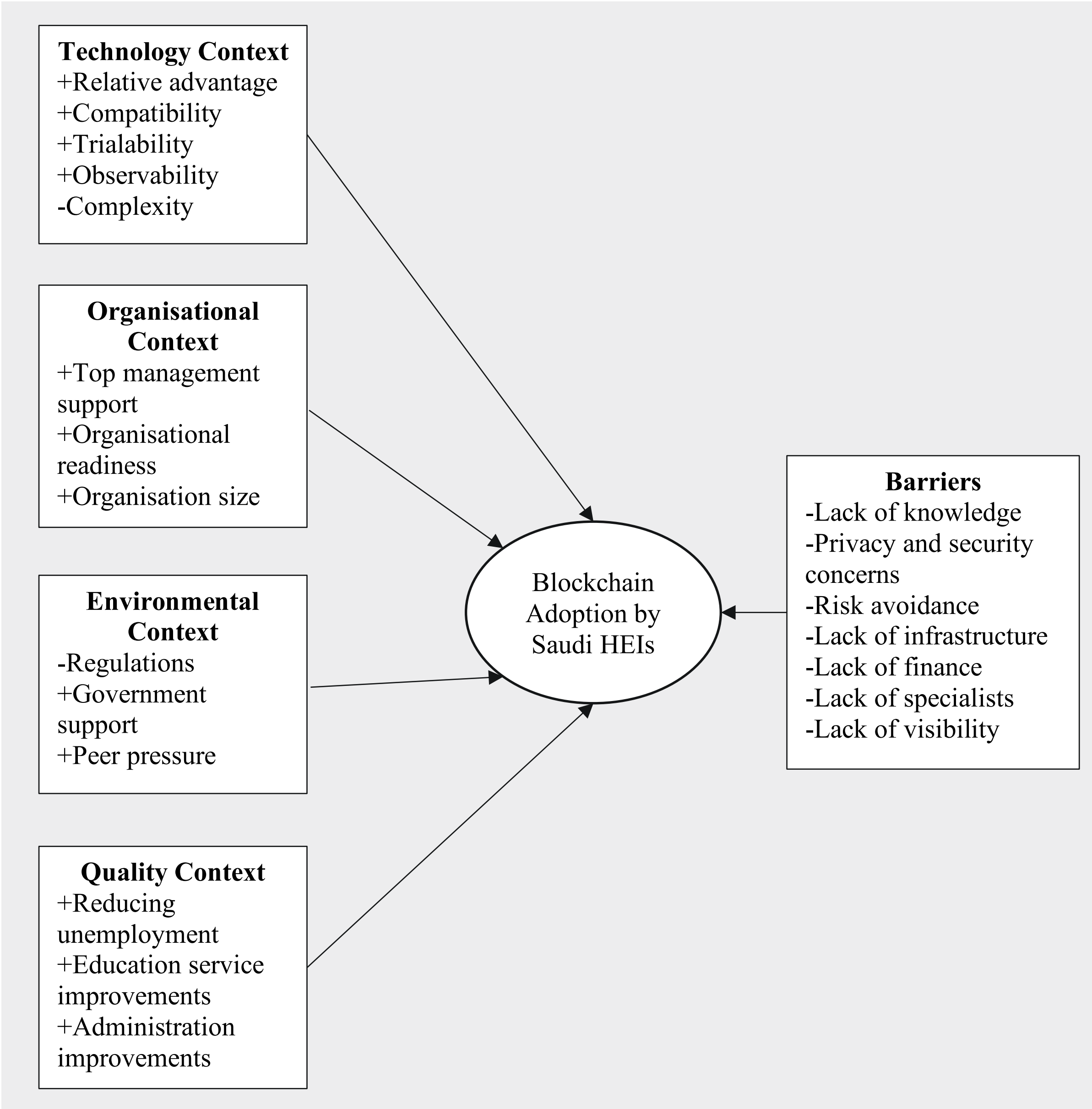


Figure 24: Original Blockchain Adoption Model by Saudi HEIs

5.2.1 Technological Context

Technological features are important for the adoption process. Visible technologies that can demonstrate value in excess of associated costs of implementation have a better chance of adoption. To investigate the effect of the technological context on blockchain adoption in Saudi HEIs, this study considered the impact of five technology attributes described within DOI (Rogers, 1995).

Relative advantage refers to the degree to which an innovation is believed to provide more benefits for an organisation (Rogers, 1995). In this study, relative advantage can be defined as the degree to which blockchain technology is believed to be better than the existing technology systems to administer educational process and offer educational services for higher education institutes. Within DOI, relative advantage arises from weighing the innovation's perceived benefits against the expected costs of adoption, which are not necessarily financial in nature (Rogers, 2005). Different industries and organisations recognise their own, specific advantages of this technology based on their needs (Carson, Romanelli, Walsh, & Zhumaev, 2018; Clohessy & Acton, 2019). However, the prerequisite costs of blockchain adoption for HEIs may also be substantial given its relatively low level of maturity, scarce know-how and the lack of business cases (Lustenberger, Malešević, & Spychiger, 2021). Given this, the adoption of blockchain by a HEI will more likely occur if the institution considers it more advantageous to the existing technologies in use. Previous studies demonstrated the importance of perceived technology relative advantage for higher education institutions (Abdekhoda, Gholami, & Vahideh, 2018; Tarhini, Al-Badi, Al-Gharbi, & AlHinai, 2018). Moreover, the relative advantage of blockchain over other technologies has been empirically confirmed in a number of studies, including those conducted in the higher education sector (Guo & Liang, 2016; Hartley, Sawaya, & Dobrzykowski, 2021; Iansity & Lakhani, 2017; Ullah, Al-Rahmi, Alzahrani, Alfarraj, & Alblehai, 2020). Therefore, the following hypothesis is formulated:

H1a: Relative advantage has a positive influence on blockchain adoption in Saudi higher education institutions.

The second factor within the technological context is complexity which is the firm's perceived difficulty in understanding and using an innovation (Tornatzky & Fleischer, 1990). To be adopted, an innovative technology should be perceived as easy to implement and use. It follows then, that the technologies which are considered challenging and complicated have lower chances for adoption. By nature, blockchain technology heavily relies on algorithms and cryptography which could be perceived as complex by many. This brings uncertainty to potential adopters and a desire to wait and understand better how it works (Clohessy & Acton, 2019; Drescher, 2017). Therefore, perceived complexity poses a serious challenge to blockchain diffusion in organisations. In fact, complexity is one of the most commonly mentioned factors related to blockchain adoption with its negative impact clearly defined (Choi, Chung, Seyha, & Young, 2020; Duan, Zhang, Gong, Brown, & Li, 2020; Malik, Chadhar, Vatanasakdakul, & Chetty, 2021; Wamba, Queiroz, & Trinchera, 2020). Therefore, the following hypothesis is formulated:

H1b: Complexity has a negative influence on blockchain adoption in Saudi higher education institutions.

Trialability within DOI is defined as the extent to which an innovation could be tried on a small scale before wider implementation (Rogers, 2003). Logically, if organisations have an opportunity to try new technologies at little to no cost and resource requirements, they are more likely to observe its benefits and decide to adopt. DOI also posits that technology maturity plays a role: for organisations considering themselves innovators and early adopters, trialability is essential (Rogers, 2003). It has been previously demonstrated that blockchain is a rather immature technology in the higher education sector, which many see as a main obstacle because organisations postpone adoption until the proof of concept is visible (Schmitt, Mladenow, Strauss, & Schaffhauser-Linzatti, 2019). At the same time, a series of case studies performed by Clohessy and Acton (2019) demonstrated that organisations which were able to experiment with blockchain relatively effortlessly on the cloud were more likely to adopt it. Similar results were reported by Iansity and Lakhani (2017). Therefore, a higher perception of trialability can play a positive role in its adoption. The following hypothesis is formulated:

H1c: Trialability has a positive influence on blockchain adoption in Saudi higher education institutions.

Observability within DOI refers to the level of technology visibility, recognition and dissemination (Rogers, 2003). The theory proposed that technologies with tangible, detectible attributes have a better chance of faster adoption. Contemporary blockchain researchers have noted difficulties related to the observability of its effects (Dobrovnik, Herold, Fürst, & Kummer, 2018; Lustenberger, Malešević, & Spychiger, 2021). According to Rauchs et al. (2019), the main issue with blockchain applications is that their tangible benefits are only observed after a while. Because of this, many blockchain-related projects are rejected without an opportunity to demonstrate the results. Given this, a higher level of blockchain observability should increase the likelihood of its adoption. Therefore, the following hypothesis is formulated:

H1d: Observability has a positive influence on blockchain adoption in Saudi higher education institutions.

The final technology context factor in the framework is compatibility. Within DOI, Compatibility refers to the degree to which a new innovation is perceived as congruent with the values, previous experiences, and requirements of potential adopters (Rogers 1995). Because these values and needs differ across industries and organisations, the compatibility feature is important in the adoption process. When it comes to blockchain adoption, researchers identified concerns related to its incompatibility with the existing technical requirements and requirements related to data protection and management (Lustenberger et al., 2021; Rauchs et al., 2019). There are also concerns related to the absence of universal blockchain standards and, as a result, the availability of many blockchain solutions which may not be fully compatible with each other and existing organisational IT infrastructures (Holotiuk, Pisani, & Moormann, 2018). A number of researchers have lately proposed that blockchain technology could benefit greatly if it became perceived as compatible with organisational infrastructures and requirements (Hartley, Sawaya, & Dobrzykowski, 2021; Kouhizadeh, Saberi, & Sarkis, 2021; Morabito, 2017). Therefore, the following hypothesis is formulated:

H1e: Compatibility has a positive influence on blockchain adoption in Saudi higher education institutions.

5.2.2 Organisational Context

While technology features are important for its adoption, the adopters themselves should be ready for the process. Indeed, the integration of innovations with the existing organisational processes, structures and strategy represents a challenging task for management teams (Lalic & Marjanovic, 2010). Therefore, the successful adoption of new technology requires the presence of key success factors within the organisational context. Organisational context factors in this study are adopted from the TOE theory and framework. According to TOE, organisational context includes organisational resources, operations and features that play roles in innovation adoption (Tornatzky & Fleischer, 1990). Top management support, organisational readiness and organisation size are considered the key determinants of blockchain adoption in this study.

Top management support is the degree to which senior management has a positive attitude towards a technology and its envisioning as contributory to organisational success (Tashkandi & Al-Jabri, 2015). It is generally seen as a major factor for success of all types of innovation projects in organisations (Chen, Xu, Lu, & Chen, 2018; Crosby, Nachiappan Pattanayak, Verma, & Kalyanaraman, 2016). Top managers promote the quality and effectiveness of innovative solutions by overcoming possible resistance within their organisation, creating a vision for the innovation and providing the required resources (Dong, Neufeld, & Higgins, 2009). Further, top management support ensures adequate adoption planning and execution (Lustenberger, Malešević, & Spychiger, 2021). This factor has received much attention in the blockchain adoption studies as well. A number of researchers found that higher levels of top management support are associated with higher likelihood of its adoption (Clohessy & Acton, 2019; Hartley, Sawaya, & Dobrzykowski, 2021; Iansity & Lakhani, 2017; Wamba, Queiroz, & Trinchera, 2020). Therefore, the following hypothesis is formulated:

H2a: Top management support has a positive influence on blockchain adoption in Saudi higher education institutions.

Within TOE, organisational readiness is a comprehensive variable that includes different aspects of preparedness to adopt innovations (Tornatzky & Fleischer, 1990). It can be envisioned in the form of adaptiveness of the culture, structures and processes to new technology adoption or in form of possessing sufficient resources for adoption (Iacovou, Benbasat, & Dexter, 1995; Weiner, 2009). These resources comprise finance, experience, knowledge, expertise and technology, all of which are allocated to the innovation in question (Lustenberger, Malešević, & Spychiger, 2021). Blockchain, being a relatively young, immature technology with a high degree of uncertainty, definitely requires a higher level of organisational readiness. In fact, organisational readiness is considered the top organisational context factor of blockchain adoption per mentions in the literature (Clohessy, Treiblmaier, Acton, & Rogers, 2020). Available studies confirmed the positive role of organisational readiness in the blockchain adoption process (Clohessy & Acton, 2019; Crosby, Nachiappan Pattanayak, Verma, & Kalyanaraman, 2016; Kouhizadeh, Saberi, & Sarkis, 2021; Zheng, Xie, Dai, Chen, & Wang, 2018). Therefore, the following hypothesis is formulated:

H2b: Higher education institution readiness has a positive influence on blockchain adoption in Saudi higher education institutions.

The final factor in the organisational context influencing blockchain adoption is organisational size. It can be defined in terms of controlled assets, workers, market share, total sales or other meaningful indicators (Bose & Luo, 2011). Within TOE, it is expected that larger organisations are better suited to adopting innovations, especially at the early stages of the diffusion process (Baker, 2012; Tornatzky & Fleischer, 1990). This is because they have a larger amount of resources, a broader knowledge base, higher levels of investment ability, and more developed infrastructures (Lee & Xia, 2006; Wang, Chen, & Xu, 2016; Zheng, Xie, Dai, Chen, & Wang, 2018). Some studies questioned this postulate by arguing that smaller organisations are more capable of adopting innovations due to agility, flexibility and control over resources and decision making (Clohessy, Acton, & Morgan, 2017; Post, Smit, & Zoet, 2018). In relation to blockchain, however, the majority of recent studies confirm the assertion that larger organisational size is positively associated with adoption (Barnes & Xiao, 2019; Clohessy & Acton, 2019; Hartley, Sawaya, & Dobrzykowski, 2021; Pilkington, 2016). In this study, organisational size is defined by the number of students, which in Saudi Arabia also reflects the amount of financial, human, and technological resources available. Accordingly, a larger size is expected to contribute to blockchain adoption. Therefore, the following hypothesis is formulated:

H2c: Higher education institution size has a positive influence on blockchain adoption in Saudi higher education institutions.

5.2.3 Environmental Context

Environmental context refers to the external factors that influence the adoption of innovation in an institution (Tornatzky & Fleischer, 1990). These factors are important for two reasons. First, they are capable of influencing an organisation’s decision to adopt innovation by exerting outside pressure; second, they are usually beyond the organisation’s control and, therefore, cannot be effectively countered. Based on TOE, three environmental context factors are considered influential to blockchain adoption in this study: existing regulations, government support and peer pressure.

Emerging technologies which bring discontinuous changes to industries often represent challenges for governments and legal systems because of uncertainty as to how to align them with the existing laws and regulations (Piscini, Cotteleer, & Holdowsky, 2018). Accordingly, it becomes difficult to forecast what the state of the regulatory environment will be as the innovation in question becomes more widespread (Lustenberger, Malešević, & Spychiger, 2021). For this reason, regulatory environment is often seen as a negative factor for innovative technology adoption. It is well known that blockchain today still lacks a definitive regulatory framework, Saudi Arabia not being an exception in this case. The existing legal concerns are related to blockchain's distributive nature, data protection and taxation among others (Salmon & Myers, 2019). As a result, analyses of blockchain theoretical applications and use cases often mention regulatory uncertainty as an impediment to its adoption (Guo & Liang, 2016; Hackius & Petersen, 2017; Kouhizadeh, Saberi, & Sarkis, 2021). It is, therefore, logical to assume that the stronger the regulatory uncertainty regarding blockchain is, the stronger the negative impact on adoption will be. The following hypothesis is formulated:

H3a: Existing regulations have a negative influence on blockchain adoption in Saudi higher education institutions.

Government support can generally be thought of as a series of actions of various character directed at stimulating technology adoption. This support can come in different forms, including legal changes, subsidising innovations or mandating them (Barnes & Xiao, 2019; Farooque, Jain, Zhang, & Li, 2020). Typically, government support serves as a strong factor in technology adoption (Barnes & Xiao, 2019; Clohessy & Acton, 2019). Given the novel nature of blockchain and the uncertainty that many organisations assign to it, government support could mitigate some of the risks associated with its adoption at the early stage of the diffusion process. This was discussed in a number of papers on blockchain adoption where a stronger degree of government support was seen as a desirable factor (Chen, Xu, Lu, & Chen, 2018; Choi, Chung, Seyha, & Young, 2020; Malik, Chadhar, Vatanasakdakul, & Chetty, 2021; Morabito, 2017). Therefore, it is expected that government support will be associated with stronger blockchain adoption. The following hypothesis is formulated:

H3b: Government support has a positive influence on blockchain adoption in Saudi higher education institutions.

The final environmental context factor is peer pressure. In general terms, peer pressure is the influence exerted by partners, competitors and other organisations to adopt an innovation (Sarkis, González-Torre, & Adenso-Diaz, 2010). Partners can pressure an organisation to adopt novel technologies for stronger integration or to achieve compatibility with more up-to-date systems (Iacovou, Benbasat, & Dexter, 1995). This is especially true where partners exert a dominant relationship and there is a higher level of dependency on them. In this case, technology adoption is more likely as the organisation will try to maintain the partnership. At the same time, a partner’s support may serve as an additional factor in fostering adoption (Hartley, Sawaya, & Dobrzykowski, 2021). On the other hand, competitors may exert pressure to adopt an innovation if they implement it *en masse* and/or there are visible positive results of adoption. In this case, the innovation may quickly become a norm for a particular industry (Chen, Xu, Lu, & Chen, 2018). Researchers of blockchain adoption in different industries acknowledged the role of peer pressure in the form of partners’ pressure, industry pressure and competitive pressure (Barnes & Xiao, 2019; Crosby, Nachiappan Pattanayak, Verma, & Kalyanaraman, 2016; Kouhizadeh, Saberi, & Sarkis, 2021; Lustenberger, Malešević, & Spychiger, 2021). Therefore, it is expected that peer pressure stimulates blockchain adoption. The following hypothesis is formulated:

H3c: Peer Pressure has a positive influence on blockchain adoption in Saudi higher education institutions.

5.2.4 Quality Context

Quality context is a sector-specific context introduced in this study. Based on the available literature on quality measures for HEIs and public data for the Saudi education sector, this study proposes that the quality context includes the following variables: 1) intent to reduce graduate’s unemployment; 2) intent to improve HEI administration efficiencies; and 3) intent to improve HEI service quality.

Improving access to the labour market and empowering students are considered key indicators of education quality (Al-Ramahi & Odeh, 2020; Harvey & Green, 1993). Unemployment reduction is one of the key issues for Saudi higher education to solve. According to the latest data, youth unemployment (individuals under 24 years) in Saudi Arabia is about 28%, and half of these individuals possess at least a bachelor’s degree (O'Neill, 2022). As an innovation, blockchain has the potential to address this issue at least partially. Two mechanisms could make this possible. First, blockchain offers an accelerated, easily verifiable system of learning credentials and certificates (Abreu, Coutinho, & Bezerra, 2020; Cheng, Lu, Xiang, & Song, 2020; Saleh, Ghazali, & Rana, 2020). Such systems make it easy for employers to verify students' skills and education, prevent fraud and help match the best candidates with open positions (Balon, Kalinowski, & Paprocka, 2020). It also supports students' career decisions and personalised career recommendations based on learning achievements (Alammary, Alhazmi, Almasri, & Gillani, 2019; Mikroyannidis, Domingue, Bachler, & Quick, 2018). Second, blockchain itself can create numerous job opportunities related to engineering, software development, education, administration and related fields (Bucea-Manea-Tonis, et al., 2021; Salah, Ahmed, & ElDashan, 2020; Shabaltina, Madiyarova, & Tamer, 2021). Therefore, it is expected that intent to reduce graduates' unemployment will stimulate blockchain adoption. The following hypothesis is formulated:

H4a: Intent to reduce the graduate unemployment rate has a positive influence on blockchain adoption in Saudi higher education institutions.

As discussed in Section 4.4.3 , education quality is envisioned through five components: excellence, perfection, value for money, fitness for purpose and institutional outcomes (Harvey, 2006; Harvey, 2007; Harvey & Knight, 1996). Innovative technologies can serve to enhance one or more of these components thereby improving a HEI's competitive position. In fact, the adoption of innovative technologies is seen as a point of differentiation and competitive advantage in the education sector (Tsinidou, Gerogiannis, & Fitsilis, 2010; Waller, Lemoine, Mense, & Richardson, 2019). Two mechanisms for this are possible: 1) HEIs can improve administration efficiencies to reduce the cost of operations (and possibly tuition cost) and 2) HEIs can improve service quality by offering novel approaches to education and the products of education. There is evidence that blockchain technology can serve both purposes. In terms of operational efficiencies, blockchain has shown very promising results due to its inherent features allowing intermediaries to be eliminated (Alammary, Alhazmi, Almasri, & Gillani, 2019; Awaji, Solaiman, & Albshri, 2020; Ma & Fang, 2020). Likewise, there is also growing evidence that blockchain adoption has brought service improvements in healthcare, supply chains, and other sectors (Loizou, Karastoyanova, & Schizas, 2019; Tandon, Dhir, Najmul Islam, & Mäntymäki, 2020; Tijan, Aksentievic, Ivanic, & Jardas, 2019). Therefore, it is expected that HEIs' intent to improve administration efficiencies and service quality will serve as stimulating factors for blockchain adoption. The following hypotheses are formulated:

H4b: Intent to improve administration quality has a positive impact on blockchain adoption by Saudi HEIs.

H4c: Intent to improve service quality has a positive impact on blockchain adoption by Saudi HEIs

5.2.5 Barriers to Adoption

Despite its potential benefits for higher education, blockchain has yet to receive widespread adoption in the industry (Alammary, Alhazmi, Almasri, & Gillani, 2019; Ullah, Al-Rahmi, Alzahrani, Alfarraj, & Alblehai, 2020). While it can be argued that the technology still remains in its early stages of the diffusion process, it is also likely that a series of factors may slow down its acceptance. Within DOI and TOE, some barriers to adoption are already embedded in the respective frameworks: examples are technology complexity and government regulations. However, research on blockchain applications has identified more potential barriers within each of the key dimensions (Choi et al., 2020; Clohessy et al., 2020). This study, therefore, considered the most commonly mentioned barriers in the literature and put them into a separate factor dimension. This was done for practical purposes: listing the relevant barriers separately allows decision makers to devise specific steps to overcome them.

Knowledge about technology is an important feature that distinguishes adopter categories within DOI (Rogers, 2003). Innovators and early adopters are the ones who acquire knowledge about technology and its benefits faster and, therefore, are first to adopt them. As knowledge spreads further, other categories join the process. Consequently, a lack of knowledge is usually considered one of the main factors which slows technology adoption, including technologies potentially beneficial to higher education (Abrahams, 2010; O'Doherty, Dromey, & Lougheed, 2018). With regard to blockchain, Alam (2022) argued that "many educational stakeholders are ignorant of the benefits and possibilities of blockchain technology owing to a lack of knowledge of this technology" (p. 307). Similarly, Choi et al. (2020) proposed that the lack of general and technical knowledge about blockchain is one of the main organisational level factors of adoption. The need to improve blockchain knowledge among organisations for faster adoption was emphasised by several other researchers (Guo & Liang, 2016; O'Dair, Beaven, Neilson, Osborne, & Pacifico, 2016; Tapscott & Tapscott, 2016). Therefore, given both the theoretical and empirical evidence regarding the relationship between knowledge about technology and its adoption, it is assumed that the lack of knowledge about blockchain will be a barrier to its adoption. The following hypothesis is formulated:

H5a: Lack of knowledge about blockchain has a negative impact on blockchain adoption by Saudi HEIs.

Another major negative factor related to blockchain adoption is privacy and security concerns. These are interrelated concerns focusing on who gets access to data and whether there are sufficient mechanisms to protect the data from being used for malicious purposes (Shin, 2019). Privacy and security concerns affect adoption decision making at both individual and organisational levels in higher education institutions (Becker, Newton, & Sawang, 2013; Qasem, Abdullah, Jusoh, Atan, & Asadi, 2019; Singh & Hardaker, 2014). Being a “trustless” type of system, blockchain enables transparent transactions between parties that do not have to know and/or trust each other (Sillaber, Waltl, Treiblmaier, Gallersdörfer, & Felderer, 2021). Further, blockchain system participants are able to review the previous transactions and their participants, especially in public blockchains (Iansity & Lakhani, 2017). While some researchers and practitioners believe that such level of distributed trust and transparency are beneficial, others argue that it is a weakness (Kosba, Miller, Shi, Wen, & Papamanthou, 2016; Underwood, 2016). Some authors specifically pointed to extremely high levels of visibility in blockchain networks as a roadblock for many organisations to join the adoption trend (Babich & Hilary, 2019; Choi, Chung, Seyha, & Young, 2020). Further, some researchers pointed to a possibility of entering dubious or erroneous code into smart contracts as a possible security concern due to the immutability of the system (Surujnath, 2017). Finally, privacy and security concerns are found to be the top individual factor which affects organisational decision makers when it comes to blockchain (Clohessy, Treiblmaier, Acton, & Rogers, 2020). Therefore, the following hypothesis is formulated:

H5b: Privacy and security concerns have a negative impact on blockchain adoption by Saudi HEIs.

Risk is one of the factors associated with adopting innovations within DOI (Rogers, 2003). The earlier adopters are usually more prone to take risks while the later majority category prefers to avoid risk at all costs. These are generalised observations, however, as risk is treated differently by individuals and organisations (Prewett, Prescott, & Phillips, 2020). At the organisational level, risk is a multi-layered concept which involves various hazards: business risks, financial risks, operational risks, legal risks being some. Typically, an organisation tries to minimise these hazards or their negative possible effects, which is known as risk avoidance (Sun, 2021). Arguably, blockchain technology carries a number of uncertainties for organisations related to implementation, governance and benefits (Alammary, Alhazmi, Almasri, & Gillani, 2019). Accordingly, perceived risks emerge in many areas associated with blockchain adoption and use. Moreover, blockchain dismantles the traditional notions of trust and the associated third-party institutional support (Sadhya & Sadhya, 2018). Therefore, it is expected that the desire of organisations to avoid risk will negatively influence blockchain adoption. The following hypothesis is formulated:

H5c: Risk avoidance has a negative impact on blockchain adoption by Saudi HEIs.

For some organisations, the perceived benefits of blockchain adoption may still outweigh the aforementioned concerns. However, even if an organisation is willing to adopt a technology, it must possess adequate resources for its successful implementation. Weiner (2009) proposed that if an organisation intends to successfully adopt an innovation, at least three types of resources should be available: human resources (knowledge and skills), financial resources (money and budget) and infrastructural resources (technologies). When one or more of these factors is absent, the change of successful adoption diminishes (Clohessy & Acton, 2019). There is a lack of research on the specific influence of each of these factors on blockchain adoption in education. However, some general evidence may offer insights. Babich et al. (2019) found that resistance to blockchain adoption may arise from a lack of workers' expertise. Likewise, Prewett et al. (2020) argued that without a sufficiently qualified workforce, organisations will be unable to extract the full benefit from blockchain applications. Further, a lack of appropriate IT infrastructure as an impediment to blockchain adoption was emphasised by several authors (Iansity & Lakhani, 2017; Lindman, Tuunainen, & Rossi, 2017; Swan, 2015). Finally, if an organisation lacks finances, it may not be able to acquire either the necessary human resources or technology to support successful blockchain adoption (Choi, Chung, Seyha, & Young, 2020; Hughes, et al., 2019). Therefore, it is expected that a lack of appropriate technology infrastructure, finances and/or human specialists will be detrimental to blockchain adoption. Accordingly, the following hypotheses are formulated:

H5d: Lack of IT infrastructure has a negative impact on blockchain adoption by Saudi HEIs.

H5e: Lack of financing has a negative impact on blockchain adoption by Saudi HEIs.

H5f: Lack of human resources has a negative impact on blockchain adoption by Saudi HEIs.

Finally, successful technology adoption may be derailed by the lack of its visibility. According to DOI, technologies that are visible and have detectable benefits and attributes have a higher chance of adoption (Rogers, 2003). This is because visibility creates knowledge and increases confidence in the applicability and ability of technology to meet the needs of potential adopters. Since blockchain is still in its early stages of dissemination in higher education, its visibility may still be limited. Some researchers specifically attributed the slower degree of blockchain adoption to the fact that colleges and universities do not see how the technology works and what kind of benefits it offers (Dobrovnik et al., 2018; Lustenberger et al., 2021). Rauchs et al. (2019) suggested that blockchain diffusion is low because it takes time to recognise the real benefits of its use. The lack of visibility due to the relatively low number of successful business use cases of blockchain was recognised in a number of works (Iansity & Lakhani, 2017; Kamble, Gunasekaran, & Arha, 2018; Zheng, Xie, Dai, Chen, & Wang, 2018). Choi et al. (2020) found that the lack of business examples of successful blockchain application reduces management commitment and support. Therefore, it is expected that the lack of blockchain visibility may adversely influence blockchain adoption. The following hypothesis is formulated:

H5g: Lack of visibility has a negative impact on blockchain adoption by Saudi HEIs.

5.3 Chapter Summary

This chapter presented the original model of blockchain adoption by Saudi HEIs. The model was developed on the basis of the theoretical and empirical literature on adoption in higher education. Five dimensions and 21 factors influencing the adoption process were identified, and their role was justified. Accordingly, hypotheses were formulated to explore the significance and role of each factor and dimension as a whole on the adoption of blockchain in Saudi HEIs.

The next chapter presents the results of the model presentation and analysis by a group of technology and HEI administration experts.

6 Research PHASE 1: Model Presentation and Analysis

6.1 Introduction

This chapter offers a review of the qualitative data collection and analysis. The process involved a series of interviews following the Blockchain Adoption Model presentation to a number of industry experts. The main two goals of the qualitative data analysis were to single out the most promising areas for blockchain applications in Saudi higher education institutions (HEI) and to determine the most important factors of adoption according to the decision makers. Section 6.2 describes the interview sample, that is, the individuals who participated in the study. Section 6.3 describes the results of the interviews: 1) the participants' views on the most viable areas of blockchain application in higher education and 2) an analysis of the factors that could be influential in the blockchain adoption process by Saudi HEIs. Section 6.4 presents the refined model of blockchain adoption following the interview results. The refined model includes the new factors proposed by the interviewees and removes some of the factors that the interviewees did not consider important. Finally, Section 6.5 presents the final version of the questionnaire to evaluate the model on a large population. The questionnaire includes the items corresponding to the finalised set of factors after the interviews.

Sections of this chapter have earlier been published in the following conferences articles:

Alalyan, M.S., Jaafari, N.A., Hussain, F.K. (2023). Technology factors influencing Saudi higher education institutions' adoption of blockchain technology: A qualitative study. *Advanced Information Networking and Applications (AINA)*. Cham: Springer International Publishing, pp. 197-207.

Alalyan, M. S., Jaafari, N. A., & Hussain, F. K. (2023). Barriers to blockchain adoption by Saudi higher education institutions: A structural equation analysis. *Advances in Networked- based information systems.,* In press.

6.2 Data Collection Results and Sample Description

In total, 10 interviews were conducted with the mid-level and senior-level administrative and information technology (IT) specialists from Saudi HEIs. Following the general recommendations in the literature (Brinkmann & Kvale, 2015; Weller, et al., 2018), a data saturation approach was applied. No substantially new insights on the topic were obtained and no new themes emerged during the tenth interview, after which it was concluded that the data saturation point was reached. The collected data were deemed sufficient for qualitative analysis.

The sample of the interviewed individuals is displayed in Table 20.The sample was balanced in terms of position and type of institution. There were three high-level administrative personnel interviewees and seven information technology specialists representing the middle and high levels of responsibility. Eight individuals in the sample represented public universities, and two represented private universities. This proportion approximately corresponded to the general distribution of private and public HEIs in Saudi Arabia as discussed in Chapter 2. Five interviewees described their level of knowledge about blockchain as adequate, average, or familiar while the remaining described it as good or excellent. As such, the participants possessed a sufficient level of blockchain expertise for the purpose of the study.

Table 20: Interview Sample

N	Name	Position	Institution	Institution Type	Level of Blockchain Knowledge
1	P1	IT Support	Department of Education	Ministry	Some
2	P2	IT Deanship Web Developer	King Khalid University	Public	Some
3	P3	IT Deanship	Islamic University of Riyadh	Public	Good
4	P4	Technical Support	King Khalid University	Public	Some
5	P5	Head of Computer Science Department	Taif University	Public	Good
6	P6	IT Administrator	KAUST	Private	Some
7	P7	Service Desk Manager	King Khalid University	Public	Some
8	P8	Dean of Computer Science and Engineering	Hail University	Public	Good
9	P9	IT Project Manager	KAUST	Private	Good
10	P10	e-Learning Specialist	King Khalid University	Public	Good

6.3 Data Analysis

6.3.1 Basic Approach

As discussed in Chapter 4, qualitative data analysis followed the approach developed by Miles and Huberman (2019). The first step in the qualitative data analysis involved data reduction and organisation, which was followed by pattern coding and, finally, data display and interpretation. To better contribute to the study goals and to meet the needs of qualitative data collection and analysis, two types of analysis are presented below. The first part describes the interviewees' perceptions regarding potential blockchain benefits and areas of application for Saudi HEIs. The second part involves descriptive conceptualisations of independent dimensions and constructs related to blockchain adoption as well as identifying the potential links among these constructs in the process of blockchain adoption.

6.3.2 Blockchain Benefits and Potential Applications

At the onset of the interview, the participants were asked about their thoughts regarding blockchain use in education globally and Saudi Arabia in particular. In total, 8 out of 10 interviewees were ready to speak on this subject. The general consensus among the interviewees was that blockchain is just starting to make its way into the education area. The adjectives used to describe the adoption level were "generally low" (4 interviewees), "some" or "partial" (2 interviewees) and "in its infancy" (2 interviewees). P3 suggested that the level of adoption is "probably higher in the developed nations" whereas P8 proposed that public universities would be less prone to adopt blockchain because of "a somewhat cautious bureaucracy and waiting for some results and to observe some applications at other universities." She saw it as one of the main reasons that Saudi HEIs are behind in terms of blockchain adoption in comparison to other countries' HEIs. In relation to Saudi HEIs, 4 interviewees had no knowledge about any blockchain uses, whereas 2 interviewees thought that blockchain could be used to some extent, but they were not sure where or how. Only 4 respondents were able to confidently speak about blockchain use in Saudi HEIs, particularly about certificates at KAUST.

Table 21 provides a list of codes developed from the analysed interview transcripts for blockchain benefits and potential areas of application dimensions. Of the 10 interviewees, 8 spoke about the ways that Saudi HEIs could benefit from blockchain. Five types of benefits were mentioned. The majority of interviewees (7 out of 8) mentioned security improvements in relation to data, records and transactions (BEN-SEC coding). Additionally, 6 out of 8 interviewees spoke about the benefits of faster, more efficient transactions (BEN-EFF coding); improvements in data management, its verification, retention and access (BEN-DAT coding); and the decentralisation of trust with no need to rely on a third party for confirmation (BEN-DEC coding). Fewer interviewees (3 out of 8) also mentioned the benefit of information exchange between HEIs, employers, and students (BEN-EXC coding).

Table 21: The List of Codes for the Blockchain Benefits and Potential Areas of Application Dimensions

Code	Meaning	Mentions
BEN	Perceived Blockchain Benefits	8
BEN-SEC	Security of data, records, transactions	7
BEN-EFF	Efficiency of transactions: speed, time	6
BEN-DAT	Data management improvements: verification, retention, access	6
BEN-DEC	Decentralisation of trust: absence of third-party reliance necessity	6
BEN-EXC	Information exchange, confirmation, approvals	3
ADP	Application Areas	10
ADP-CER	Certificates, diplomas	10
ADP-IPP	Intellectual property protection	9
ADP-ADM	Administrative procedures	8
ADP-EVA	Student evaluations	7
ADP-ENH	Enhanced learning applications	6
ADP-LRN	Learning and assessments	4
ADP-SMT	Smart environments	4

In the next step, the interviewees were asked to identify the potential areas of application for blockchain in Saudi HEIs with the goal of determining the most feasible application areas for further investigation. Based on the review of the available literature on the theoretical and practical applications of blockchain in education, seven topics were discussed. The results are reviewed below.

The most commonly mentioned application was in relation to ***certificates and diplomas***, which was discussed by all interviewees. Specifically, the interviewees mentioned such areas as diploma issue, confirmation and immutability. In this regard, some notable responses included[2]:

> *Firstly, to preserve the environment from the waste that happens... Also, the diploma will be reserved at the student, non-perishable, not lost… It solves many problems with blockchain certificates.* (P3)
> *... there is a saving of time and very high security and maintaining the*

[2] Hereafter, direct quotes from the interview transcripts are provided. Some language errors are likely because for the interviewees, English is not their native tongue.

certificates from forgery or impersonation, for example, and this is possibly one of the most important things I mean in the certificates. (P4)
Blockchain is essential to apply in certificates because it helps students deliver theirs anytime and from anywhere. (P5)
From my point of view now, I mean, it is considered the easiest, and the first application always for universities, mainly for the blockchain, is on certificates and accreditation of university certificates. Because it is a straightforward application, the verification process is also much easier than any other product and app. (P8)

Intellectual property protection was the second most commonly mentioned blockchain application with 9 interviewees discussing it, although there was apparently less confidence in how it could be used and to what effect. Those who clearly supported blockchain use for academic intellectual property protection (5 interviewees) linked it mostly to the idea of an overall blockchain-enhanced digital ID which also offers a higher degree of protection:

When it is in ID and this advanced thought will work and will help that the one means that there is protection, protection of data. (P1)
Every student should have a digital ID that allows the student to keep his certificate, transcript, and research. In the future, this makes it easy for the student to search and apply for a job very quickly. (P4)
I think it's a good technology because it has high security and has more credibility in protecting researchers' rights. (P9)

At the same time, some interviewees expressed doubts about whether blockchain can enhance intellectual property protection in academia because of other means of protection:

Different methods can be used for intellectual property protection. However, I feel it is still jurisprudence. I feel that it has not become more transparent [...] for the person who owns the idea. [...] Even I have a record registered with intellectual property. (P2)
In terms of research and scientific theses, they inevitably maintain that when there is a quotation, it is a documented quotation, not without the knowledge of its author. (P6)

Yet others thought that intellectual property protection is not on the blockchain agenda of HEIs because they have other, more urgent priorities:

Intellectual property protection is not a priority to apply to blockchain because, at the moment, there are many technologies used to protect intellectual property. (P5)
It is not essential to me as a university official at the moment. However, at the moment, I need university certificates, academic records,

> *admission, and the process of student admission and registration.* (P8)

Yet another frequently mentioned area of application was ***school administration***, which was discussed by 8 of the 10 respondents. The interviewees discussed the promising applications in the registration process (6 interviewees), admissions (4 interviewees), data extraction and verification, grade confirmations and transfers (1 each). Blockchain was seen as a technology to enhance transparency, improve student data security, and reduce transaction times for data transfer, confirmation and verification. Some examples of the responses are:

> *For example, if we have a student who wants to register at university, suppose that we have converted electronic certificates and papers that I need to accept and register electronically. Blockchain made it easier for that student to securely apply once to all universities.* (P3)
> *In student registration, blockchain means the easy extraction of data. And verification data. If corruption occurs, all the data will not be damaged or lost, especially when the student graduated a long time ago.* (P6)
> *I give 10 for Administration, because it is a saving of time and a transparency provision.* (P8)

Blockchain uses for ***student evaluations*** were discussed by 7 interviewees. While 5 of the interviewees expressed positive views regarding blockchain applications in this area, only two were able to distinguish them from the already existing online technologies. Specifically, features such as prevention from grade and achievement manipulation and continuous skill and achievement update were discussed:

> *Blockchain helps to prevent the grades from being manipulated. The grades and achievements cannot be changed.*
> *There is a significant point: we can change and benefit from blockchain with artificial intelligence in evaluating the student and in giving him or developing his skills. This means, I can tell the student from the day he enters the university that you will have a file of your skills.* (P3)

Others referred to the already existing online features and technologies without making specific references to blockchain:

> *Technology will make it easier for the faculty member to correct assignments and tests online, publish the grades and make them easily accessible for students.* (P5)
> *Evaluating students with tests and assignments can contribute to speeding up the correction process and thus reduce the correction burden on the faculty member.* (P9)
> *Because we currently have online student evaluations, the faculty will enter the grades and evaluations at different stages of the learning process*

> *to track and demonstrate the student progress.* (P10)

One interviewee also expressed an opinion that blockchain is *"not essential"* for student evaluations, and other, more urgent applications should be considered.

The interviewees also spoke about blockchain applications for ***enhanced learning*** environments (6 interviewees in total). Of these, 4 considered blockchain as an important tool given that education is moving increasingly online and new methods of reliable, effective content delivery are in demand:

> *Based on the features of the blockchain, it is better than Blackboard. Because Blackboard suffered a lot last year, you know the system is frozen, continuous pressure, sure blockchain will work.* (P1)
> *In the Covid-19 pandemic, we needed all the educational environments to become online, whether in quizzes or assignments. The exams help a lot that when each student has a unique record in it from the beginning of the study to the time of his graduation, he will have this experience that he can refer to when he is looking for a job.* (P2)
> *The whole world has carried technology with it in every place and uses technology in every place. […]. For example, or you are working on the project electronically. Some programs and applications help with this thing. Moreover, I expect that even if they meet as a class as a form of attendance physically. I expect that they will also use the technologies, whether the Blockchain or the programs that help them record the meeting* (P3)

Others, however, expressed more cautious opinions. P8 stated that "*there is no clear, observable path for blockchain use in enhancing existing learning environments*" at this point in time. Similarly, P10 argued that "an increasing number of commercially available enhanced learning systems are being offered in the distance education market" thereby meaning that demand for blockchain applications may not be sufficient.

Only 4 interviewees spoke about blockchain's potential applications for ***students' learning and assessments***. Of these, however, only 2 expressed confidence in blockchain's real contributions, mostly in terms of tracking students' progress and keeping educational achievements in one place:

> *Look at the Covid-19 pandemic. It showed us the need to check all education achievements in one place. This differentiates blockchain from other technologies. You can keep all learning records ever and make them available for check in literally one click.* (P3)
> *For those who keep educating themselves, through online courses or different platforms, they would want to add information to one place,*

> *update it, and then make it presentable and verifiable. This is where blockchain becomes very useful.* (P1)

The remaining 2 interviewees acknowledged blockchain had some potential for verifiable CVs which could be updated and verified immediately after new education milestones are achieved. At the same time, they noted that it is not something being developed at the moment:

> *Take the job platforms where people post their CVs to find jobs. Blockchain may ensure that these CVs are up to date and free from misinformation. Maybe with time, they can come to it, but I see that it's not ready right now.* (P10)
> *Colleges and universities have other priorities when it comes to blockchain. In the future, yes, you may see how students progress with specific learning topics and include their learning achievements in lifelong learning blockchain. However, it is not the foreseeable future as I see it. There are other instruments available.* (P8)

Finally, 4 interviewees discussed the use of blockchain to create ***smart learning environments***. However, such discussions mostly concentrated on distant future applications rather than something expected in HEI soon. The interviewees acknowledged the idea, but stated that it was too early to consider it seriously:

> *A university must first start applying blockchain technology in all its electronic, administrative, and educational transactions. Then it will reach the point of being a smart university.* (P5)
> *At the current time, no, I see no feasible blockchain-enhanced smart universities. However, in the long run, hopefully, it will be possible. At present, people still have ignorance in blockchain technology and how to apply it to the whole education process.* (P1)
> *I cannot find examples of smart universities now, I mean, they are not 100% smart. [...] However, if the trend emerges, and you are able to quickly explore it and implement it, you will be very successful.* (P3)

Based on the analysis of the interviewees' perceptions of blockchain potential applications in HEI, several important themes emerged:

Theme 1: blockchain is still an emergent topic among IT professionals and HEI administrators in Saudi Arabia.

Of the 10 interviewees, only 5 expressed a deep understanding of the topic, whereas another 5 acknowledged somewhat limited knowledge. There was no consistent understanding among the interviewees regarding blockchain adoption in education, including Saudi Arabia. Some were not able to tell in which particular areas blockchain is being currently used and applied in education. With some exceptions, the interviewees spoke of blockchain as a type of new technology which needs to be investigated and researched further rather than something being readily adopted and applied.

Theme 2: the primary benefits of blockchain for education, as recognised by the interviewees, are its decentralised nature and security trust mechanism.

The interviewees considered these aspects of blockchain as particularly useful in managing student records and credentials and offering novel ways to enhance administrative tasks and learning processes. Specifically, the mechanisms of security, immutability and fast verification within the network were acknowledged. On the other hand, not all interviewees were able to directly relate the particular aspects of blockchain to novel applications in education. Sometimes, there was little clarity about how exactly blockchain implementation would be different from the already existing learning technologies.

Theme 3: the most promising area for blockchain applications in Saudi HEI is blockchain certificates and diplomas.

During the interviews, the participants were asked to name the potential blockchain application areas for higher education and rate them. A summary of these assessments is presented in Table 22. As can be seen, blockchain-supported school certificates and diplomas were the only higher education area mentioned by all interviewees and consistently received the highest scores. Blockchain applications for administrative tasks and academic intellectual property protection were other commonly mentioned areas, although there was a certain amount of disagreement among the interviewees regarding their potential and viability. Other potential areas of blockchain applications were not discussed as much and/or lacked substantial consensus regarding benefits and uses.

Based on the themes developed during the analysis, it was decided to proceed with the focus on blockchain applications for university diplomas and certificates.

Table 22: Interviewees' Assessments of Blockchain Potential for Higher Education Aspects

Interviewee	Certificates	Administrative Tasks	Learning and Assessment	Student Evaluation	Enhanced Learning	IP Protection	Smart Environment
P1	10	10	10	8.5	10	10	-*
P2	10	-	-	-	10	8	-
P3	10	10	10	10	8.5	10	10
P4	10	8	-	-	yes**	10	yes
P5	10	8	-	yes	-	-	5
P6	10	10	-	9	-	6	-
P7	10	10	-	-	-	-	-
P8	10	10	6	6	6	6	6
P9	10	-	-	10	-	10	-
P10	10	10	8	10	10	10	-
Total Evaluations	10	8	4	7	6	8	4

* '-' indicates that the interviewee did not provide any discussion on the topic
** 'yes' indicates that the interviewee mentioned the area of application but did not rate/evaluate its potential

6.3.3 Factors Influencing Blockchain Adoption in Saudi HEI

Based on the theoretical underpinnings of the study, the interviewees were asked about the influence of multiple factors on blockchain adoption by Saudi HEIs. Additionally, the interviewees were asked to offer their own input about any additional factors they found significant in this process. As a result, six blocks of factors were discussed. The following analysis of each block of factors is based on Miles and Huberman's (2019) approach where 1) data reduction was applied reduce the data into an analysable format; 2) pattern coding was applied to develop themes from the content analysis; and 3) summaries of codes and underlying themes were presented in the form of tables for visualisation and interpretation.

For the data reduction process, operational codes were developed to identify constructs related to blockchain adoption. Additional coding was developed to identify the strength of each considered factor in relation to blockchain adoption in HEI. Four types of codes were developed in this regard:

- Strong effect value was assigned to constructs which were identified by the interviewees as "strong," "very important," "important", "essential," "extremely,", "imperative" and similar adjectives.

- Moderate effect value was assigned to constructs which were discussed by the interviewees using words “moderate,” “not very strong,” “sensible,” “restrained,” “average” and similar terms.
- Unclear effect value was assigned to constructs which were discussed by the interviewees using such terms as “unclear,” “not sure,” “maybe,” “perhaps”, “probably,” “could be” and similar terms.
- Finally, no effect value was assigned to constructs whose influence was clearly denied by the interviewees.

The analysis also demonstrates the mechanisms through which the aforementioned effect values were assigned by the study participants.

6.3.3.1 Technological Factors

Data codes and the frequency with which technological factors were mentioned are listed in Table 23. The coding is ranked based on factor strength. As can be seen, *complexity* was the most discussed technology effect in the context of blockchain adoption, although *relative advantage* by far was the most consistently mentioned and the most highly rated. Overall, none of the theoretically established technology factors was considered to be weak or irrelevant by the study participants.

Table 23: Coding Applied to Technology Dimension Factors

			Strength of Effect on Adoption			
Code	**Meaning**	**N**	**Strong**	**Moderate**	**None**	**Unclear**
TECH-RA	Relative Advantage	7	7	-	-	-
TECH-COMP	Compatibility	9	5	-	3	1
TECH-OBS	Observability	8	2	2	2	2
TECH-CPX	Complexity	10	3	3	3	1
TECH-TRIA	Trialability	8	3	3	1	1

Several themes clearly emerged in relation to the effect of *relative advantage* on blockchain adoption by HEI. Five interviewees considered it an “essential technology” for future applications whereas the other two called it a “very important” aspect of blockchain. Blockchain’s relative advantage was discussed in the context of catering to the growing amount of education moving online, specific needs of HEIs in managing the process, and overall being forward looking, value adding technology with next-level security mechanisms:

> *Relative advantage is an essential factor. Because trust, privacy, and security in blockchain are high. It is essential in terms of the policies that we always work with cybersecurity and in any conflict.* (P2)
> *Speaking of the relative advantage of blockchain, first of all, it can cater to specific business needs. As an administrator, for example, I know what the needs of my university are. Like, let me say, for example, my University is a women's University. I am sure that our University's has specific needs. So, I know first of all what I need in technology for blockchain, and depending on the need, I specify where I can apply it.* (P7)
> *Relative advantage is an essential factor. Because sometimes, it is not a requirement that any trendy technology will be compatible with existing applications. Sometimes it's ok; it saves time and it offers decentralization.* (P8)
> *Blockchain also has the advantage of being distinguishable from the rest of the technologies we have, and this feature may support us in its application which is purely digital technology. This will be an added value for the University, especially if one of the objectives of the University is to be a digital university.* (P9)

Given the high value assigned by the interviewees to the relative advantage factor in blockchain adoption by HEI, it was decided to retain this factor in the final conceptual framework for the study.

With regard to compatibility, the opinions of the study participants were divided. Of the 9 interviewees, 5 considered it a strong factor in the blockchain adoption process. They spoke about blockchain's compatibility with their institutions' goals and objectives, administrative procedures and educational services:

> *I think that in our case, in our university, blockchain is compatible with the University, our vision, message, goals, and so on.* (P1)
> *Compatibility is an essential factor. I mean, it generally is if it integrates with the existing infrastructure in the administration. Is the administration ready to integrate blockchain? Sure, in our case I think it is. I think that this factor is essential: its compatibility with the university infrastructure.* (P2)
> *Compatibility is an essential factor. At least in my area of responsibility, which is service provision: education services and supplemental services. Blockchain should be compatible with what we do and, better, with the existing systems we use.* (P7)
> *Of course, compatibility matters, especially if this technology allows the connection of other tools, I mean, connectibility to other different systems. (P10)*

On the other hand, some interviewees denied compatibility had a meaningful impact or stated that it was much weaker in comparison to relative advantage:

> *I do not think that compatibility is necessary for applying blockchain technology. Because blockchain technology can be applied and adapted to match the environment in which it is applied.* (P5)
> *With regards to compatibility… Well, in our case if our school uses a new technology, so, it must not affect the old systems. It will probably replace them outright. So, not that essential of a factor. (P6)*
> *I think that incompatibility or compatibility is not an obstacle or things that may affect the adoption of the technology.* (P8)

Accordingly, the themes that emerged in the discussion of the compatibility factor in blockchain adoption were: 1) compatibility is sought in all aspects of HEI management: from services to administration thereby making compatibility an important factor in blockchain adoption; 2) from a technical standpoint, compatibility with the existing systems may not be that important for decision makers. Given the importance assigned by the interviewees to compatability, it was decided to retain it for the final conceptual model of the study. However, the influence of the factor in the final model would not be expected to be as high as the relative advantage factor.

Blockchain observability in the adoption process was discussed by 9 interviewees. The opinions regarding its effect were clearly divided. Some interviewees argued about the strong influence of observability, especially in view of the positive effects in other institutions or in some areas of their own institution:

> *If a new technology appears, we must keep pace with it, especially if it is applied in a university. Moreover, suppose I noticed that this university succeeded in using the technology, facilitated many tasks, and reduced costs. In that case, it will encourage the university to apply it because it saw an experiment in other universities in the same region and sector.* (P6)
> *Hundred percent, observability matters. In our university we applied many technologies with this. […] Say, this tool is helping you do your job comfortably; you do it efficiently. If there is convincing evidence that it was applied well in some area, then definitely, we will consider its use in other areas.* (P7)

Others were somewhat cautious about the effect of the observability factor

> *Ok, I can see, for example, KAUST or University of Taibah or any university that has adopted the use blockchain technology. I may start to see how their results and benefits are, but it's not that it will be the deciding factor or the only factor influencing our decision to adopt.* (P2)
> *If we see the benefits of blockchain applications, it may not necessarily be what we are looking for. We will first consider how blockchain is applied and whether we use the same applications and systems, whether it will benefit us the same. It's a long process, actually, with many variables*

> *involved.* (P3)

Some interviewees were unsure about the overall effect:

> *I am not sure about the influence of observability. Maybe when the decision-makers see that many universities in Saudi Arabia applied the blockchain and had success, that may help them adapt to their university because they know its benefits. Again, however, it is not clear right now.* (P4)
>
> *Adoption of new technologies is based more on politics. […] Most Saudi universities are public, and they pursue a somewhat cautious bureaucracy by waiting for some results and making observations of some applications at other universities. Based on these experiences and observations, technologies can be launched. But it will depend on the bureaucratic procedures and state support.* (P8)

Yet others denied the effect of observability altogether, arguing that their HEIs follow their own technology adoption plans:

> *My university does not care whether other universities apply a new technology or not. It is always searching for development on its own.* (P1)
>
> *In my opinion, observing successful technology adoption may motivate universities to apply it, but it is unnecessary, especially if a university has a strong IT department and implements new technologies regardless.* (P5)

Therefore, the following themes emerged during the interviews with regard to observability in relation to blockchain adoption by HEIs: 1) the effect of the observability factor remains unclear; 2) observability will matter if blockchain benefits can be observed both within and outside of a particular HEI; 3) it may take time for a HEI to realise blockchain benefits by observing its effect; and 4) for some HEIs, observability may not matter at all if they have a strong IT development strategy. Based on the analysis, observability was retained in the final conceptual model, although its effect was expected to be moderate.

Technology complexity was discussed by all interviewees in the context of blockchain adoption by HEIs. The opinions, once again, were divided. Those who opined about the influence of the complexity factor agreed that the impact of complexity would be negative; that is, the more complex blockchain is considered to be, the weaker the administrators' desire to adopt it will be. However, disagreements arose about the strength of this impact. Those who spoke of a strong impact argued that it would be difficult for users to understand and use:

> *This factor will negatively impact technology adoption. When the technology is challenging to use and understand and needs a specific infrastructure and competencies, financially expensive, it may be a reason for the delay in applying this technology. […] I see that this is the case with blockchain at the moment. (P4)*
> *I expect perceived complexity to be an important factor. Many institutions still do not know exactly what difficulties they may face with this technology and the weaknesses in this technology. (P5)*
> *Complexity is a significant factor because blockchain is still emerging so it could be hard for users to understand it. (P9)*

Several interviewees also acknowledged the impact of complexity, although they thought it would be moderate because of specialist and user training and the learning process:

> *It is a possible factor, yes. Blockchain is ambiguous. However, I think the impact of complexity can be negated, so it is a question whether there is a specialist who can manage blockchain.* (P2)
> *Blockchain needs effort in training academic staff, members, and students. In the beginning, they may encounter problems, but with time this will diminish.* (P6)
> *There is some complexity, perceived complexity barrier in the beginning. But it may not be as strong if users understand it quickly. So, it is a matter of learning curve.* (P10)

Yet others did not believe complexity would be a factor in the adoption process. They argued that generally, in the age of technology, complexity is becoming archaic because users are becoming increasingly technology savvy and because it is possible to hire appropriate specialists at the institutional level:

> *Complexity as a factor? No, no, no. We live in the age of technology, and complexity is a sentence that does not exist in our technology-driven life. Users, especially young people, they are too well versed with all kinds of emergent technologies.* (P2)
> *No, complexity cannot stand in the way. Because the whole world is almost electronic, it is impossible that the complexity of the blockchain would be an obstacle to its adoption. Because we can use experts who can arrange training for the staff you have or make the matter easier for you.* (P3)
> *Right now, I think the complexity of technology is not important. Because each university has an IT department, the staff who work there are rather familiar with new technology, and you can train them easily. We have no problem. As long as these staff have been sufficiently trained, the complexities, even if they exist, will not be an obstacle*. (P8)

In the course of the analysis, the following themes emerged: 1) perceived blockchain complexity negatively affects its adoption and it arises from the novelty of the technology and users not being able to understand it outright; 2) the negative impact of complexity can be diminished through training and learning; and 3) the stronger a HEI's IT department is believed to be, the lower the impact of complexity is expected to be. The complexity factor was retained in the final conceptual model with the expected negative impact on blockchain adoption.

The final technology factor discussed by the interviewees was the trialability of blockchain. In general, the majority of study participants supported the effect of this factor, although to different degrees. Those who argued in favour of a strong influence, connected it to the necessity of trying any new potentially impactful technology on a limited basis:

> *Of course, this factor is essential because any new technology must be tested or experimented with to know if this technology is applicable and to what extent and benefit. (P5)*
> *Yes, it is necessary that technology can be tried out. For example, we have three-phase trials in our university tech department for all new technologies. If we see that it has good potential, it has a high chance of being implemented. (P7)*
> *Trialability is very, very, very important. Any new technology is always applied on a limited scale after we see benefits from it and start applying it in a broader form. (P8)*

Those who believe that trialability only had a moderate degree of influence mostly argued that almost any technology could be tried out, at least from the experience in their HEIs:

> *Usually, the scenario that we have adopted uses any new technology that we use in the infrastructure; whatever we need is a demo. We present it to the decision-makers, whether the university director or the vice-dean in the administration if they give us the approval and that it is complete. We do not have any problem.* (P2)
> *We do a trial for all applications. It is extensive and quick. But, as I said, all applications are triable.* (P3)
> *Trialability is a factor, to some extent. We, of course, test new technologies to see what they help achieve and how. I do not, however, recollect, any difficulties in trying and testing new technologies.* (P6)

Finally, one interviewee did not believe that trialability should be a concern exactly because new technologies are all tried routinely at her HEI:

> *No, trialability is an anachronism. We try all technologies that we consider prospective, no exception. We test them quickly and then transfer them to the other parties with the most specific features that serve them.* (P10)

In the course of the analysis, the following themes emerged: 1) trialability is an influential factor in blockchain adoption, although the strength of the influence is not clear; 2) HEIs that routinely test emerging technologies for school applications are better positioned to ignore the trialability factor.

All pattern codes and their underlying themes are summarised in Table 24, showing that all five factors proposed within the Rogers (1995) model were retained for the final analysis, although the expected strength of each factor varied.

Table 24: Data Summary for Technology Factors

Pattern Codes	Themes	Factor Decision
Relative advantage -> blockchain adoption	- Perceived as the strongest technology factor for blockchain adoption; - catering to the growing amount of education moving online; - corresponding to specific needs of HEIs in managing the process; - the advantage overall comes from being forward looking, value adding technology with next-level security mechanisms.	RETAINED in the final model within the technology dimension. Strong relationship to adoption expected.
Compatibility -> blockchain adoption	- compatibility is sought in all aspects of HEI management: from services to administration thereby making compatibility an important factor in blockchain adoption; - from a technical standpoint, compatibility with the existing systems may not be that important for the decision makers.	RETAINED in the final model within the technology dimension. Moderate relationship to adoption expected.
Observability -> blockchain adoption	- the effect of observability factor remains unclear; - observability will matter if blockchain benefits can be observed both within and outside of a particular HEI; - it may take time for a HEI to realise blockchain benefits by observing its effect; - for some HEIs, observability may not matter at all if they have a strong IT development strategy.	RETAINED in the final model within the technology dimension. Moderate relationship to adoption expected.
Complexity -> blockchain adoption	- perceived blockchain complexity negatively affects its adoption and it arises from the technology novelty and users not being able to understand it outright; - the negative impact of complexity can be diminished through training and learning; - the stronger a HEI's IT department is believed to be, the lower the impact of complexity is expected to be.	RETAINED in the final model within the technology dimension. Negative relationship to adoption expected.
Trialability -> blockchain adoption	- trialability is an influential factor in blockchain adoption, although the strength of the influence is not clear; - HEIs that routinely test emerging technologies for school applications are better positioned to ignore the trialability factor.	RETAINED in the final model within the technology dimension. Moderate relationship to adoption expected.

6.3.3.2 Organisational Factors

Data codes and the frequency with which organisational factors were mentioned are listed in Table 25. The coding is ranked based on factor strength. It can be seen that *top management support* was the most discussed and the most supported factor within the organisational dimension. Organisational readiness was another factor with perceived strong influence. However, organisational size was not as strongly perceived. Pattern coding and theme development for each factor in relation to blockchain adoption based on the interviews data are provided next.

Table 25: Coding Applied to Organisational Dimension Factors

			Strength of Effect on Adoption			
Code	**Meaning**	**N**	**Strong**	**Moderate**	**None**	**Unclear**
ORG-TMS	Top Management Support	10	9	1	-	-
ORG-REA	Organisational Readiness	8	6	1	-	1
ORG-Size	Organisational Size	10	3	-	4	3

Top management support was almost universally seen by the study participants as a strong influential factor in blockchain adoption. As a matter of fact, it was considered important in the context of all technologies. The interviewees discussed top management support using the adjectives like “essential,” “necessary,” “significant” and “most important.” The majority agreed that without top management support, it is impossible to integrate new technologies in Saudi HEIs in general. Some typical comments in this regard were:

> *Top management support is essential. We can't move and can't do anything unless the senior management gives us authority and supports us*. (P1)
> *If a question about implementing some new technology arises, it is necessary that it be with the support of the senior management*. (P5)
> *If top management is not sufficiently convinced of new technologies, we will have great difficulty implementing them*. (P8)
> *For me, this is the most important factor. If there is no top management support for a new technology, forget about it*. (P9)

Some respondents also mentioned senior’s management general desire to try and adopt new perspective technologies, although they must be convinced that those technologies have good potential:

> *At my university, they support adopting new technology. However, you have to convince them that this technology will serve them right*. (P10)
> *We are working on digital transformation according to Vision 2030, so top management is interested in new technologies. They will likely consider blockchain, but you need to be convincing about it and its specific advantages*. (P7)
> *Everything that the top management supports makes things easier. If there is support from the top management, I feel that it will be easy to apply any new technology such as blockchain. But the question is how you "sell" it to them*. (P4)

Overall, in the course of the analysis, the following themes emerged: 1) top management support is considered the strongest and most important organisational factor for blockchain adoption; 2) top management support is generally regarded as necessary for all types of technologies in Saudi HEIs; 3) top management in Saudi HEIs is generally interested in new technologies, although they have to be given strong arguments about the benefits of these technologies. The top management support factor was retained for the final model in the analysis with an expected strong influence on blockchain adoption.

Organisational readiness was also seen as a strong factor for blockchain adoption by the study participants. The majority of the interviewees spoke about readiness in terms of the human, technology, and financial resources necessary for new technology adoption. This was usually supported by their experience in past and current technology projects in their HEIs:

> *Based on the past and ongoing technology projects in our university, I can say that financial resources, staff experience, and infrastructure would all affect the adoption of blockchain technology.* (P6)
> *New technologies other than blockchain have been applied at my university. Educational institutions always have sufficient technological, financial, human resources to apply new techniques.* (P9)
> *For any new technology a university adopts, it is necessary to know the particular resources that it needs.* (P5)

Few respondents were less particular with regard to the role of organisational readiness by mentioning that even without proper resources, institutions can still prepare for new technology adoption by training and acquiring the resources in question:

> *Some universities may lack, for example, human resources. But then you can develop a training plan and fill this gap. I think the same can be applied to other resources as well. (P1)*
> *The institution readiness factor can be remedied, solved, and dealt with preparation, training, and the development of clear action plans for it by*

> *equipping the institution. I mean, in terms of human or technical resources. (P8)*

In the course of the analysis, the following themes emerged in relation to the organisational readiness factor: 1) organisational readiness is an important factor that encompasses the human, financial, and technological resources necessary for technology adoption; 2) institutions without a proper level of readiness can still adopt new technologies by acquiring or developing such resources. Based on the analysis, the organisational readiness factor was retained for the final analysis. A strong relationship to blockchain adoption was expected.

Unlike the previously discussed organisational factors within the TOE framework, organisational size was widely regarded as either a weak or insignificant factor by the majority of interviewees. They argued that size will not matter if the institution has proper management support and sufficient resources for new technology adoption:

> *The factor of the size of the educational institution does not make much difference for as long as you have all the resources and management support available.* (P3)
> *I do not see it as very important. For example, now, we have banks and municipalities that are using blockchain technology, or at least they are trying it out. They did not care about the size of their institution. I do not think it is a significant thing. I think that the most important thing for me is the top management support and the institution's readiness.* (P4)
> *My point of view is that the size of the institution is not essential because if there is support and there is a ready environment, if there are human staff ready if there is good material support, it does not matter whether you are a 1,000-student institution or 10,000-student institution.* (P9)

Other interviewees could not decide whether an institution of a particular size would have an advantage in technology adoption:

> *Also, the factor of the size of the educational institution is also an important factor, but it is not much because it is possible to apply the technology to any sized institution.* (P5)
> *Ok, size may matter, I do not know which one is better, however. I can see positive aspects influencing new technology adoption by being either small or large institution.* (P8)

Granted, some interviewees still considered it a strong factor. However, there was no consistency among them about which sized institution would be better positioned for blockchain adoption:

> *The size of an organization affects the adoption of new technologies. Smaller universities are more agile in adopting new technologies like blockchain.* (P1)
> *If the university has many students, I will try to adopt new technology like the blockchain because my goal is to speed up and improve efficiency of certain administrative processes. Accordingly, larger universities will adapt new technologies like blockchain faster.* (P2)
> *I wish it would equally apply to small and big institutions. However, it will benefit larger institutions to a larger degree. Therefore, they will pursue it more willingly.* (P6)

In the course of the data analysis, the following themes emerged in relation to organisational size and its potential impact on blockchain adoption: 1) organisational size is generally considered as a weak, non-significant factor; 2) there are advantages for both small and large HEIs in adopting new technologies like blockchain; 3) there is no consistency about which organisational size is better positioned for new technology adoption. After careful analysis of the relevant data, it was decided to remove organisational size from the organisational dimension of the final model. However, given its possible, although unclear influence on blockchain adoption, the organisational size variable will be considered among the control variables in the quantitative data analysis.

All pattern codes and their underlying themes relevant to the organisational dimension factors are summarised in Table 26. It can be seen that two of three factors proposed in the original TOE framework were retained for the final analysis. For both top management support and organisational readiness, a strong relationship to blockchain adoption was expected.

Table 26: Data Summary for Organisational Factors

Pattern Codes	Themes	Factor Decision
Top Management Support -> blockchain adoption	- perceived as the strongest organisational factor for blockchain adoption; - generally regarded as necessary for the adoption of all types of technologies in Saudi HEI; - top management in Saudi HEIs are generally interested in new technologies, although they have to be given strong arguments about the benefits of these technologies.	RETAINED in the final model within the organisational dimension. Strong relationship to adoption expected.
Organisational Readiness -> blockchain adoption	- organisational readiness is an important factor that encompasses human, financial, and technological resources necessary for technology adoption; - institutions without a proper level of readiness can still adopt new technologies by acquiring or developing such resources.	RETAINED in the final model within the organisational dimension. Strong relationship to adoption expected.
Organisational Size -> blockchain adoption	- organisational size is generally considered as weak, non-significant factor; - there are advantages for both small and large HEIs in adopting new technologies like blockchain; - there is no consistency about which organisational size is better positioned for new technology adoption.	REMOVED from the final model's organisational dimension. Will be considered among the control variables.

6.3.3.3 Environmental Factors

Data codes and the frequency with which environmental factors are mentioned are listed in Table 27. The coding is ranked based on factor strength. It can be seen that nearly all interviewees discussed the effect of all the considered environmental factors on blockchain adoption. Existing regulations were considered as the most influential factors in this regard, although the strength of such influence was not always clear. Government support was also seen as an important factor, although some respondents disagreed. Finally, the effect of the peer pressure factor was rather ambiguous with an even distribution of supporters and opponents on its effect. Pattern coding and theme development for each factor in relation to blockchain adoption based on the interview data are provided next.

Table 27: Coding Applied to Environmental Dimension Factors

			Strength of Effect on Adoption			
Code	**Meaning**	**N**	**Strong**	**Moderate**	**None**	**Unclear**
ENV-REG	Existing regulations	10	5	3	-	2
ENV-GVT	Government support	10	4	4	2	-
ENV-PPR	Peer pressure	8	3	2	3	-

The potential effect of existing regulations was discussed by all interviewees in relation to blockchain adoption. The majority of interviewees agreed that the effect was present, although opinions differed regarding its strength. The proponents of a strong effect argued that new technologies must meet the existing requirements and that this is especially true for public HEIs in Saudi Arabia. Another argument was that HEIs have internal regulations that must be considered as well:

> *True, government regulations are barriers to the fast implementation of modern technologies. This is especially related to new technologies.* (P4)
> *Obviously, in Saudi Arabia we have the Ministry regulating technology matters. We need to carefully consider such regulations, and blockchain will not be an exception in this case.* (P3)
> *The regulations definitely represent one of the major barriers. Sometimes it can be a real hindrance to new technology adoption. However, at the very least, we need to comply with the regulations existing within the university.* (P8)

Some interviewees, however, argued that the regulations apply to specific technologies only and that it is still possible to try them out even though on a limited basis:

> *With regard to existing regulations, I should say you need to look at what specific technologies are regulated and how. Maybe they are regulated, maybe they are not, maybe only partially regulated. So, it depends, really.* (P5)
> *Whether regulations represent a really significant barrier is questionable. I am sure, and we do this at our school, you can still try new technologies on a limited basis, no problem. Regulations, they play a role when you want to launch a new technology on a wide scale, officially*. (P6)
> *Whether regulations are important, I'd say yes, but probably not as much as you may think. We, at least, have not had many issues with regulations with such things as the cloud, AI, or even IoT. We look at new tech and what laws apply to it, but it is usually not that strict*. (P7)

Finally, some respondents could not determine whether the effect would be present in relation to blockchain:

> *As you know, blockchain is a new technology. It is very new, but it has been already tried in other fields like finance, for example. I think regulations exist in relation to cryptocurrency, but I am not sure whether*

> *there are any for blockchain in education. So, I cannot speak of this confidently.* (P9)
>
> *Regulations do matter. Speaking of their effect on blockchain right now, maybe both yes and no. Yes, because I know that blockchain is somehow regulated on the financial side. No because I haven't heard of some restrictions for our field. And, besides, you know, a couple of universities already use this technology in Saudi Arabia. I do not know how it is regulated.* (P10)

Based on the analysis of the qualitative data, the following themes emerged in relation to the effect of existing regulations on blockchain adoption: 1) regulations likely matter, and they have a negative effect on technology adoption; 2) both external and internally developed regulations will likely matter; 3) the effect of regulations may be diminished because they may apply to specific technologies and their uses and because HEIs may still experiment with technologies on a limited basis. It was decided to retain the existing regulations factor in the final model. The expected effect on blockchain adoption would be moderately negative.

The effect of government support was discussed by all interviewees as well. The majority of study participants argued in favour of the positive effect of government support, although to differentextents. At the same time, there were respondents who did not consider government support a significant factor in blockchain adoption. The proponents of a strong effect argued that government support started to matter more during the pandemic as the HEIs were in dire need of new technologies to offer high quality education services online. Further, they argued that government support means more resources and less red tape in the adoption process:

> *Government support means a lot in new technology adoption. They provide the resources, sometimes financial, sometimes advice. This is very true for public universities in Saudi Arabia. But I also think it plays an increasing role for private schools as well.* (P1)
>
> *Cooperation from the Ministry of Education with educational institutions in applying technologies and keeping pace with the times is essential. During the COVID-19 pandemic, the Ministry played a major role in the transformation of distance education. I think this will continue. A lot of trust has been built between the Ministry and the universities in the past few years.* (P9)
>
> *If there was one positive effect of COVID, I would say it was the increasing role of government support. With more and more educational services moving online, government support matters more as well. We have noticed this with the application of new technologies.* (P10)

Those who felt that government support was a moderate factor proposed that HEIs often rely on internal sources in developing and applying new technologies, although they would welcome any kind of support coming from the government.

> *Speaking of government support, I'd say it is always welcome. However, we have been mostly implementing new technologies ourselves.* (P5)
> *I believe the government can be supportive in new technology implementation and adoption. At the same time, I think internal resources are more important. We rely on them, and this would likely be the case with blockchain.* (P6)

Finally, those who did not think of government support as an influential factor in blockchain adoption argued that government agencies are generally slower and more cautious when it comes to new technology adoption. Conservative policies and bureaucracy would prolong the wait for adequate support in terms of resources:

> *Speaking of anything new, government agencies are rarely supportive outright, at least in our field. New technologies are not always seen as a top priority. If we asked for additional technology or, for example, we adopted new technology, it can be presented to them. However, it will require time in terms of providing us money and taking time until approval begins.* (P10)
> *The Ministry of Education is not an obstacle when it comes to new technology adoption, but they are not very supportive either. This is how I see it. There is too much old, conservative thinking, too much bureaucracy involved. They react slowly to innovations, we need to rely on ourselves.* (P3)

Based on the analysis of the qualitative data, the following themes emerged in relation to the effect of government support on blockchain adoption: 1) government support is seen as a positive thing, although it is not always expected; 2) government support is more likely at later stages of innovation when the benefits of new technologies become obvious; 3) conservative policies and bureaucracy are seen as the main elements in the process. It was decided to retain the government support factor in the final model. The expected effect on blockchain adoption would be moderately positive.

The role of the peer pressure factor in blockchain adoption caused the most disagreement in the opinions of the interviewees. Those who argued about a strong effect of peer pressure talked about competitiveness and a strong motivation when adopting new technologies like blockchain:

> *Peer pressure is an essential factor because we are working in the same*

sector, so we need to remain competitive. If other universities apply a new technology, this is a competitive advantage. We must respond quickly. (P6)
Peer pressure is a significant factor. If blockchain is adopted by us of some other university to a great positive effect and we find it really useful and helpful, then for sure it matters because the goal, in general, is to improve development for the better. (P9)
Yes, our university looks all the time if other universities use some new tools, looks at the results, how they would have benefited from it if they had found great benefit from it, apply it here as well. (P10)

Other study participants acknowledged the effect of peer pressure but thought it did not play a very important role. The interviewees pointed to peer pressure as a reason to make decisions about riskier types of technologies with unclear potential:

I think, peer pressure is a catalyst, although to some extent only. I mean, it can stimulate the adoption of certain technologies, but mostly those where benefits are not clear. In the case of other technologies, where the effects are known and visible, you do not wait for others, you explore them timely. (P4)
Peer pressure helps convince the decision makers if some risky technology is under review. Say you do not have any significant problems and you do not intend to replace the existing technologies right now. Why should I take risks? But then I see that others are trying it, ok I will play a wait-and-see game. If they are successful, it will pressure the decision-makers to agree to use this technology. However, it is not that we see others implementing it and go for it right away. (P2)

An equal proportion of the respondents did not believe peer pressure had any substantial effect. They based their opinions on HEIs' internal programs of technology development:

Ours is a competitive field, for sure. To remain competitive, we cannot afford the wait-and-see games. (P1)
As for peer pressure, no, it's not a factor, because ultimately every institution has its own program and a plan for technologies. (P5)
With regard to peer pressure, it is unnecessary, because every university has its development plans, and they know what their technical capabilities are and know what the unique technical needs are in it. New technologies, therefore, are directed at filling the internal service and administration gaps, not to meet technology capacity of others. (P8)

Based on the analysis of the qualitative data, the following themes emerged in relation to the effect of peer pressure on blockchain adoption: 1) peer pressure could be a factor in HEIs using technology as a point of competition; 2) peer pressure probably has a stronger impact in relation to new, untried technologies with few observational benefits; 3) for tried, proven technologies, peer pressure is unnecessary because their adoption is implemented within HEIs' internal development plans. It was decided to retain the peer pressure factor in the final model. The expected effect on blockchain adoption would be moderately positive, although it could differ based on to what extent the respondents perceive blockchain to be a risky technology.

All pattern codes and their underlying themes relevant to the environment dimension factors are summarised in Table 28. In the end, all factors proposed in the original TOE framework were retained for the final analysis. A strong negative relationship was expected between the existing regulations and blockchain adoption and moderately positive relationships were expected for the relationships between government support and blockchain adoption as well as peer pressure and blockchain adoption.

Table 28: Data Summary for the Environment Factors

Pattern Codes	Themes	Factor Decision
Existing Regulations -> blockchain adoption	- regulations likely matter, and they have a negative effect on technology adoption; - both external and internally developed regulations will likely matter; - the effect of regulations may be diminished because they may apply to specific technologies and their uses and because HEIs may still experiment with technologies on a limited basis.	RETAINED in the final model within the environment dimension. Strong negative relationship to adoption expected.
Government Support -> blockchain adoption	- government support is seen as a positive thing, although it is not always expected; - government support is more likely at later stages of innovation when the benefits of new technologies become obvious; - conservative policies and bureaucracy are seen as the main elements in the process.	RETAINED in the final model within the environment dimension. Moderate positive relationship to adoption expected.
Peer Pressure -> blockchain adoption	- peer pressure could be a factor for HEIs using technology as a point of competition; - peer pressure probably has a stronger impact in relation to new, untried technologies with few observational benefits; - for tried, proven technologies, peer pressure is unnecessary because their adoption is implemented within HEIs' internal development plans.	RETAINED in the final model within the environment dimension. Moderate positive relationship to adoption expected.

6.3.3.4 Quality Factors

Three quality-related factors were discussed by the study participants: expected improvements to education quality, expected improvements to administration processes, and a reduction in graduate unemployment levels. Data codes and the frequency with which quality factors are mentioned are listed in Table 29. The coding is ranked based on the discussed factor strength. It can be observed that all three factors were perceived to have a strong influence on blockchain adoption by the interviewees. However, while the study participants clearly identified the role of blockchain in improving employment opportunities for graduates, they rarely separated education service quality from school administration quality, as will be shown later. Pattern coding and theme development for each factor in relation to blockchain adoption based on the interviews data are provided next.

Table 29: Codes Applied to Quality Dimension Factors

			Strength of Effect on Adoption			
Code	**Meaning**	**N**	**Strong**	**Moderate**	**None**	**Unclear**
QUAL-EMP	Reduced unemployment	10	7	1	-	2
QUAL-EDU	Quality of education services	8	7	1	-	-
QUAL-ADM	Quality of school administration	8	7	1	-	-

The majority of the interviewees agreed on the strong effect of blockchain's potential to reduce unemployment which, in turn, may prompt its faster adoption. The inherent features of blockchain, such as immutability and transparency, were commonly discussed as important factors in this regard:

> *Blockchain in my opinion is more transparent and more credible regarding employment. There will be a direct match of skills based on blockchain-backed credentials. Indeed, I see that a reduction of student unemployment is one of the critical quality factors in blockchain adoption.* (P4)
>
> *Blockchain technology will significantly improve education quality because blockchain education credentials will be based on impeccable evidence. Ledger-verified credentials cannot be altered or forged.* (P8)

Accordingly, the interviewees pointed to the ease and speed of the job application process and the verification of student credentials using blockchain certificates:

> *In the increasingly digitalised world, students can apply online for many jobs around the world, but this process needs the verification of skills. Traditional certificates are not that easy to confirm, it requires time and effort. Blockchain-based credentials will make the process so much easier. This is also another strong reason why universities should consider blockchain.* (P5)
> *When there is a need, the search for employees is rapidly using blockchain technology because their data and achievements are saved, accessible, and easily verified, so hiring is faster.* (P9)

One interviewee also pointed to an increased motivation for students to excel in their academic endeavours because blockchain certificates record learning progress that cannot be manipulated or altered:

> *Sure, blockchain improves the performance and operational objectives and reduces student unemployment. It helps in reducing the unemployment level by motivating students to develop and show their experiences and authenticate their experiences and certificates. That will encourage them. Determining the work shall be according to the competence and experience of this student. There is no manipulation in it.* (P6)

Some interviewees, however, could not determine the exact way that blockchain could reduce unemployment for college graduates. In all cases, they pointed to the advantages for the early adopters with an unclear effect for the majority of students:

> *Maybe there is a connection to employability, maybe it will give an advantage in the labour market. However, that will depend on blockchain's use. I am not sure many students will be eager to try it.* (P2)
> *Blockchain may increase employment chances for people who master and understand technology. But what about those who do not support this technology, do not want to develop themselves, are satisfied with their approximate situation, satisfied with their situation and so on? I do not see the automatic benefits for all these people, so only for those who are blockchain savvy. And maybe universities will understand it.* (P3)

In the course of data analysis, the following themes emerged with regard to the relationship between improvements in student employment and blockchain adoption: 1) inherent, unique features of blockchain may assist students in the employment market; 2) the most likely advantages provided by blockchain in the labour market are ease of the applicant's review process and credibility of education achievements; 3) blockchain records may additionally motivate students to excel in studies hence becoming better prepared for professional life; and 4) there is some doubt whether blockchain will benefit all students, not only those who embrace the technology early. Based on the analysis, reduced unemployment was retained in the final model with a moderate positive effect on blockchain adoption expected.

The interviewees also expressed views on the strong positive effect of blockchain on education quality and, hence, on blockchain adoption by HEIs. However, with the exception of 1 respondent, all of them talked about education quality improvements and administration improvements in the same terms and context:

> *I expect strong contribution of blockchain to quality of education. I do not mean courses only, I mean the entire process of managing, administering, delivering services.* (P3)
> *Blockchain technology will have a major role in improving the quality of education. […] during the Covid-19 pandemic, distance education has become dominant. The more universities become reliant on distance education, the stronger role blockchain may play in improving its quality.* (P4)
> *Sure, blockchain will likely improve the quality of education. Since the goal is always to improve development for the better, the application of blockchain technology will be the best solution in administrative work and services because it is more transparent and more credible and will help in the process of archiving and disposing of digital documents, reducing the likelihood of falsifying and losing papers. .* (P9)
> *Yes, we can say that blockchain will improve the quality of education because the whole education system will be almost online and provide online resources and lectures to students at any time and from any place that the student can deliver to, such as micro credentials, how it is possible for the student to enrol in short courses and courses from any university around the world and to take them online*. (P5)

Based on the analysis of the qualitative data, the following themes emerged in relation to the effect of improvements in education quality on blockchain adoption: 1) quality of education is seen as a composite of service quality and administration quality; 2) the quest for improving the quality of education will prompt HEIs to adopt blockchain as HEIs become more digitalised. Based on the analysis, it was decided to retain the combined quality of education services and quality of education administration into a single factor in the final model. The new factor is titled improving education quality. The expected effect on blockchain adoption would be positive.

All pattern codes and their underlying themes relevant to the quality dimension factors are summarised in Table 30. For the final model, three original factors were collapsed into two with the separate effects expected for reduced unemployment and improved education quality.

Table 30: Data Summary for Quality Factors

Pattern Codes	Themes	Factor Decision
Reducing graduates' unemployment -> blockchain adoption	- inherent, unique features of blockchain may assist students in labour market; - the most likely advantages provided by blockchain in the labour market are ease of the applicant's review process and credibility of education achievements; - blockchain records may additionally motivate students to excel in studies hence becoming better prepared for professional life; - there is some doubt whether blockchain will benefit all students, not only those who embrace the technology early.	RETAINED in the final model within the quality dimension. Strong positive relationship to blockchain adoption expected.
Improving quality of services -> blockchain adoption Improving HEI administration -> blockchain adoption	- quality of education is seen as a composite of service quality and administration quality; - the quest for improving the quality of education will prompt HEIs to adopt blockchain as HEIs become more digitalised.	CONVERGED into a single improving education quality factor. Strong positive relationship to blockchain adoption is expected.

6.3.3.5 Barriers to Adoption

The interviewees discussed various barriers to the adoption of blockchain technology. With a total of 11 barriers mentioned, it was possible to divide them into three groups: individual, organisational, and external. Table 31 shows the data coding for these barriers within these three groups with most frequently mentioned barriers first. Despite the multitude of barriers, only some of them were thoroughly discussed by a sufficient number of interviewees. Moreover, some barriers were similar to or paralleled the previously mentioned factors, all of which allowed them to be converged into a single factor. Therefore, in the final model, only four barriers were retained. Pattern coding and theme development for each factor in relation to blockchain adoption based on the interview data are provided next.

Table 31: Codes applied to Blockchain Adoption Barriers

			Strength of Effect on Adoption		
Code	**Meaning**	**N**	**Strong**	**Moderate**	**Unclear**
Individual Barriers					
INDB-LKN	Lack of knowledge about technology	8	2	1	5
INDB-PSC	Privacy and security concerns	7	5	1	1
INDB-LNG	Language concerns	7	5	-	2
INDB-RSK	Risk avoidance	2	-	1	1
Organisational Barriers					
ORGB-LSP	Lack of specialists	5	3	2	-
ORGB-INF	Lack of appropriate infrastructure	3	2	1	-
ORGB-LFN	Lack of finances	2	1	1	-
ORGB-LRD	Lack of general readiness	1	1	-	-
External Barriers					
EXT-FINA	Association with finance only	8	6	1	1
EXT-LVIS	Lack of visibility	4	2	-	2

In total, 4 individual barriers to blockchain adoption were discussed by the interviewees. A lack of knowledge about blockchain was the most commonly mentioned factor (8 times), although the study participants failed to mention the strength of its effect. Specifically, many interviewees agreed that blockchain is still an emergent technology, especially in Saudi Arabia, and therefore, it may take time before HEIs will start to adopt it:

> *A possible barrier is, of course, that there is insufficient information about blockchain technology. This lack of knowledge prevents administrators from exploring it.* (P5)
> *Maybe insufficient information about the blockchain is one of the barriers. Like I said, many haven't heard of it. It may be a mistake or a shortcoming on our part here in the Arab world. I hear very little about blockchain at the industry conferences and seminars. This is the strong reason why blockchain adoption may take time.* (P7)
> *It is still an emerging technology that is still mysterious and has not been widely applied, so this is the challenge for universities.* (P9)
> *One of the main things preventing blockchain adoption in colleges and universities is ignorance about the technology and its advantages. The level of ignorance is especially high here, in Saudi Arabia.* (P10)

Based on the analysis of the interviews, the following themes regarding the relationship between a lack of knowledge about blockchain and its adoption by Saudi HEIs emerged:

1) lack of knowledge generally prevents technology adoption; 2) blockchain is currently poorly understood and rarely applied; 3) however, it is not clear to what extent this may prevent its adoption. Due to the high frequency with which it was mentioned, it was decided to include lack of knowledge as a barrier to blockchain adoption in the final model. The expected direction of the effect would be negative, although the strength of the effect is difficult to predict.

Privacy and security concerns related to blockchain adoption were expressed by 7 interviewees. There was agreement that this could be a strong factor preventing blockchain adoption by some HEIs, despite the blockchain features that actually enhance both. This is based on the perception of all new technologies which are not well understood yet:

> *The concerns of privacy and security are always strong with new technologies, blockchain will not be an exception. People who know the technology will know that it is secure. However, it is difficult for those who have little idea how blockchain works. And many decision makers in Saudi Arabia's colleges and universities are like that, unfortunately.* (P2)
> *Privacy and security concerns are very important, but they are based on misunderstanding of technologies. Look, we had this problem with cloud applications before. There was a suggestion for using cloud computing, and they said 'no, it does not work because of security' OK guys, security in the cloud is greater than the existing data center. It took them several years to understand this. The same will be the case with blockchain.* (P3)
> *Privacy and security are strong in blockchain, but it is possible to imagine people having fears because they do not understand the technology […] this may be considered a serious obstacle to adopting this technology.* (P5)

Based on the analysis of the interviews, the following themes regarding the relationship between privacy and security concerns about blockchain and its adoption by Saudi HEI emerged: 1) privacy and security concerns are typical for new technologies among Saudi school administrators; 2) it may take years to realise the real privacy and security potential similar to cloud computing; 3) privacy and security concerns cause serious reservations regarding blockchain adoption. Due to the high frequency with which it was mentioned, it was decided to include privacy and security concerns as a barrier to blockchain adoption in the final model. The expected direction of the effect would be strongly negative.

Language concerns emerged as a surprising but strong factor that could prevent blockchain adoption in Saudi HEIs. The interviewees argued that there is very little information about blockchain in Arabic. They also expressed concerns that it would be difficult to find non-foreigners to implement blockchain if needed:

> *Language could be a serious problem. If we want to learn about new technology, how it works, what its benefits are, we would rather read about it in our native language, which is Arabic. However, there is so little information about blockchain in Arabic!* (P1)
> *A very novel technology blockchain might be, but where do we get specialists to implement and run it? I doubt you can find many good blockchain specialists in Saudi Arabia. There are no courses in blockchain, there is no technical literature in Arabic. Unless you get some specialists with good English skills, there is little information about it.* (P3)
> *Also, please, consider language issues. I would say that 95% maybe of all information on blockchain is in English. Most of staff here do not speak or read English.* (P4)
> *Sure, you can find a lot of information on blockchain on the internet. You can even go through some online courses. The problem? It's all in English or other languages, not in Arabic. And this is a problem because not many people are capable of reading lest understanding some difficult technical parts of it in English.* (P7)
> *It is often the case with innovative technologies coming to Saudi Arabia from abroad. Most systems are native English languages, the client of universities slowly adopts it if he does not support Arabic. There is very little information about blockchain, this is a very huge drawback for adoption.* (P10)

Based on the analysis of the interviews, the following themes regarding the relationship between language concerns and blockchain adoption by Saudi HEI emerged: 1) there is little information about blockchain in Arabic; 2) administrators would feel uncomfortable implementing technologies without thorough descriptions available in their native language; 3) the language barrier in relation to blockchain may be a reason for the shortage of good blockchain specialists. Due to high frequency with which it was mentioned, it was decided to include language concerns as a barrier to blockchain adoption in the final model. The expected direction of the effect would be strongly negative.

Fewer interviewees (4 in total) discussed general risk avoidance by school administrators as a potential impediment to blockchain adoption. While there were opinions that risk avoidance could be a strong factor preventing the adoption of new technologies, those opinions largely matched the ones expressed during the discussions of the peer pressure factor. Specifically, the interviewees believed that risk avoidance with new technologies is one of the major reasons that school administrators may wait and see the effects of technology on other HEIs:

> *School administrators here in Saudi Arabia are very risk averse. They would rather miss opportunities than take the blame for something they implement and which does not work properly. Therefore, they would generally prefer to be slow with new technologies like blockchain and just wait before they become widespread.* (P5)
> *I believe that risk avoidance by university tops could be a barrier. Basically, they would rather watch how the untried technologies work if they are implemented by others. They would rather not take risks on their own.* (P8)

Because risk avoidance was very close semantically to discussions on other factors and because it was discussed by a few interviewees only, it was decided to not include this factor in the final model among the potential barriers to blockchain adoption by Saudi HEIs.

Four types of organisational barriers to blockchain adoption were identified during the interviews: lack of specialists, lack of appropriate infrastructure, lack of finances, and lack of general readiness of a HEI. None of these barriers, however, was distinctively different from the factors discussed in the organisational dimension. Specifically, all these factors were reverse of the organisational readiness aspects:

> *The existing infrastructure could be a challenge. I mean, the current systems may not be well suited for blockchain.* (P2)
> *University infrastructure may not be commensurate with blockchain technology. It could make universities unable to use them*. (P4)
> *Technical resources, finance resources, staff experiences, you name it. This subject needs further study, what is required for its successful implementation? What kind of resources?* (P6)
> *As I've already mentioned, technical readiness is important. If there is insufficient technical competence of staff, especially since we are talking about new technology like blockchain, then this will be an issue.* (P8)
> *Even if blockchain is really good and useful, if your organisation is not generally ready for new technology, then you would have to pass on it, at least for some time.* (P7)
> *One of the reasons for not adopting new technology could be the lack of cadres. But let's say, you have technically competent staff. Maybe you do not have sufficient budget for implementation or maybe the university will not assign sufficient funds for some reason. So, human and financial resources are the key: you do not have either one in sufficient amount, no successful blockchain adoption will be possible*. (P10)

Because there were no distinctive aspects of the organisational level barriers from the requirements mentioned in the organisational factors dimension, it was decided that these barriers would not be included in the final model.

The final group of barriers to adoption discussed by the interviewees were external factors, of which HEIs have little or no control. Blockchain's association with finance only and its lack of visibility were the two barriers mentioned. Association with finance emerged as a unique, technology-specific barrier for blockchain adoption discussed by 8 study participants. Almost all of them considered blockchain's association with finance as a strong barrier to adoption. Specifically, the respondents talked about blockchain being associated with cryptocurrencies and its perceived absence of useful applications for education:

> *For many people, even those who know about blockchain, this is something from the investing field. Bitcoin, cryptocurrency, maybe financial transactions. But few really think of it as an application for the educational field.* (P1)
> *True, one of the main challenges is that we often talk about blockchain in the context of bitcoin. And, actually, the majority of information about blockchain is about this. I understand this is because of the incredible growth of bitcoin in the past years. Because of this, who would think of blockchain for education instead of gaining personal wealth?* (P2)
> *I would also argue that […] blockchain is strongly linked to the financial field in human minds. This is what it was created for in the first place. Sure, it is moving to other fields as well, but the majority still believe it is a financial instrument, not an instrument for the educational field. This, in turn, is a barrier to adoption, a very strong barrier. I mean, until human perceptions of blockchain change.* (P6)
> *You know, some universities in Saudi Arabia already use blockchain. But you go and ask people how blockchain is used, and almost everyone will answer that it is a bitcoin instrument. They will find it hard to speak of blockchain applications for education.* (P10)

Based on the analysis of the interviews, the following themes regarding the relationship between blockchain's association with finance and its adoption by Saudi HEIs emerged: 1) blockchain is strongly associated with finance; 2) many people, even those familiar with blockchain, find it difficult to talk about its useful applications or benefits for the educational field; and 3) this type of thinking prevents forward-looking actions directed at blockchain adoption by HEIs. Due to high frequency with which it was mentioned, it was decided to include association with finance as a barrier to blockchain adoption in the final model. The expected direction of the effect would be strongly negative.

Fewer respondents talked about the lack of blockchain's visibility, and only 2 acknowledged that this could be a serious barrier:

> *How do you make a technology adopted? Through knowledge of course. You see it, see its potential, you adopt it. With blockchain technology, all the world still has ignorance about it. It is not somewhere on social media or in the news, I mean for general audiences. It is for a limited number of specialists for now.* (P1)
> *There is no blockchain visibility, really. Compared to cloud computing, for example. Almost everyone knows what it is. But, again, a few years ago, it was the same situation. Today, since the cloud is everywhere, everyone knows about it, everyone adopts it increasingly. For blockchain, no such visibility is a problem.* (P6)

The other two interviewees took a more cautious approach in this regard by noting that HEIs may adopt blockchain not for the masses, but to serve their own needs thereby reducing the need for visibility:

> *I admit that blockchain has not yet received due prominence, especially in the financial field. Few know about it. But again, if we talk about a university, like our university, for example, we adopt technologies to serve internal needs, be it services or administration, or something else. So, the mass visibility of technology is not a big barrier.* (P8)
> *I am not sure that blockchain should be really a widespread, much discussed technology before schools start using it. The reason is simple: blockchain applications may be used to solve internal technology gaps. In some aspects, yes, it must be visible, especially when it involves users such as students. In other aspects, however, like improving security aspects of school servers, this may not be required.* (P9)

Because only a few interviewees discussed the lack of blockchain visibility as a barrier and because there was no consensus about it being a significant barrier, this factor was not included in the final model for the study.

Table 32 summarises the pattern codes, themes, and decisions regarding the inclusion of the potential barriers to blockchain adoption in the final model. From the original 10 barriers, 4 were retained for the analysis. The decisions were based on the number of interviewees discussing the factors, the depth of the discussions, and the uniqueness of each factor to improve the descriptive power of the model.

Table 32: Pattern Codes, Themes, and Decision Regarding Barriers to Adoption Factors

Pattern Codes	Themes	Factor Decision
Lack of knowledge -> blockchain adoption	lack of knowledge generally prevents technology adoption; blockchain is currently poorly understood and rarely applied; however, it is not clear to what extent this may prevent its adoption.	INCLUDED in the final model.
Privacy and security concerns -> blockchain adoption	privacy and security concerns are typical for new technologies among Saudi school administrators; it may take years to realise the real privacy and security potential similar to cloud computing; privacy and security concerns cause serious reservations regarding blockchain adoption.	INCLUDED in the final model.
Language concerns -> blockchain adoption	there is little information about blockchain in Arabic; administrators would feel uncomfortable implementing technologies without thorough descriptions available in their native language; the language barrier in relation to blockchain may be a reason for the shortage of good blockchain specialists.	INCLUDED in the final model.
Risk avoidance -> blockchain adoption	school administrators are generally risk averse when it comes to new technologies; they would prefer to wait and see how their peers do with the technology in question.	EXCLUDED from the final model
Lack of specialists -> blockchain adoption	being a new technology for education, blockchain specialists in this field are scarce; it may take time and resources to achieve the required level of technical competence with the existing staff.	EXCLUDED from the final model
Lack of appropriate infrastructure -> blockchain adoption	if a HEI lacks the appropriate infrastructure, new technology has little chance of being implemented; appropriate infrastructure must include systems and processes conducive to blockchain use which is often not the case.	EXCLUDED from the final model
Lack of finances -> blockchain adoption	the lack of funds prevents investments in new technologies and processes; school administrators may not issue funds if they are not fully confident that the technology will succeed.	EXCLUDED from the final model
Lack of general readiness -> blockchain adoption	general readiness arises from a combination of human, financial, and infrastructure factors; if these factors, wholly or partially, are not present, there will be issues with technology adoption.	EXCLUDED from the final model
Association with finance only -> blockchain adoption	blockchain is strongly associated with finance; many people, even those familiar with blockchain, find it difficult to talk about its useful applications or benefits for educational field; this type of thinking prevents forward-looking actions directed at blockchain adoption by HEIs.	INCLUDED in the final model.
Lack of visibility -> blockchain adoption	blockchain lacks visibility unlike other technologies such as cloud computing; visibility is apparent especially important in the education field; visibility may matter less if a HEI seeks a technology to improve its internal processes.	EXCLUDED from the final model

6.4 Finalised Conceptual Model

Based on the analysis of qualitative data, the original conceptual model was amended to take into account the insights acquired from the Saudi HEI specialists. In sum, the following changes were applied:

1) The organisational factors dimension was reduced to two factors by eliminating the size variable which was considered either weak or non-substantial in blockchain adoption by the interviewees;
2) The quality dimension was reduced from three to two factors by combining improvements to education and improvements to administration into a single factor titled improvements to education quality;
3) The human factors dimension was dissolved with the innovativeness feature included in the top management support factor and technical competence included into organisational readiness factor;
4) Four out of ten factors were retained in the barriers to adoption dimension. Other factors were eliminated or integrated with other factors based on the interviewees' input.

The final conceptual model which served as a basis for quantitative data analysis is presented in Figure 25. The model consists of five dimensions: technology factors, organisational factors, environment factors, quality factors, and barriers to adoption. The influence of sixteen variables across these dimensions on blockchain adoption in Saudi HEIs will be analysed based on quantitative data from a large-scale survey.

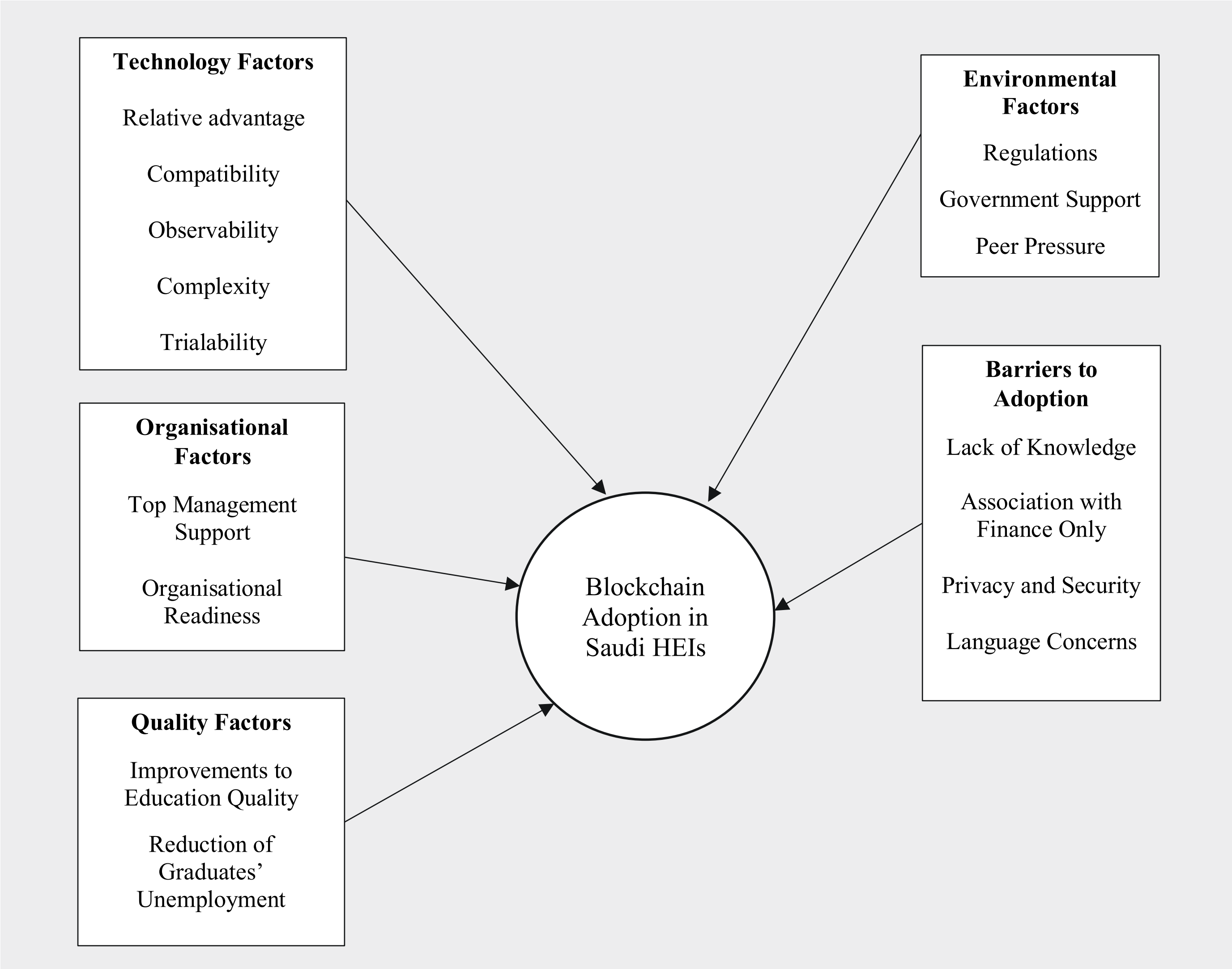


Figure 25: Finalised Conceptual Model for the Study

6.5 Finalised Questionnaire

Based on the finalised conceptual model presented in Figure 25, the instrument for the quantitative data analysis was developed. Previously validated TOE, DOI, and quality assurance questionnaires were taken as a basis for item development in this study. Because of the lack of research on blockchain adoption in higher education, the literature pertaining to the adoption of other new technologies (cloud computing, smart campus etc.) in higher education was consulted. Table 33 lists the study constructs with the corresponding studies from which the items were extracted.

Table 33. List of Variables and Sources for Item Development

Context	Variable	Sources
Technological	Relative advantage	Crosby et al. (2016), Iansity and Lakhani (2017), Lustenberger et al. (2021)
	Compatibility	Guo and Liang (2016), Shrier et al. (2016)
	Complexity	Drescher (2017), Kouhizadeh et al. (2021), Wong et al. (2020)
	Observability	Lou and Li (2017), Lustenberger et al. (2021), Rauchs et al. (2019)
	Trialability	Clohessy and Acton (2019), Lustenberger et al. (2021), Schmitt et al. (2019)
Organisational	Top management support	Duan et al. (2020), Kouhizadeh et al. (2020), Wang et al. (2020),
	Institution readiness	Mendling (2017), Kouhizadeh et al. (2021), Webster and Gardner (2019)
	Institution size	Crosby et al. (2016), Iansity and Lakhani (2017), Morabito (2017)
Environmental	Existing regulations	Hiran and Henten (2019); Mendling et al. (20180, Wong et al. (2019)
	Peer pressure	Clohessy and Acton (2019), Kouhizadeh et al. (2021)
	Government support	Shrier et al. (2016), Tapscott and Tapscott (2016)
Quality	Service quality improvement	Al-Ramahi and Odeh (2020); Harvey (2007)
	Unemployment reduction	Al-Ramahi and Odeh (2020), Lindman et al. (2017)
Barriers	Lack of knowledge	AlTaei et al. (2019), Delaghani et al. (2022); Li et al. (2019)
	Privacy and security concerns	Kokina et al. (2017), Lindman et al. (2017), Reddick et al. (2019)
	Association with finance	Ma and Fang (2020); Raimundo and Rosario (2021)
	Language barriers	Alenezi et al. (2021), Hiran (2021)
Adoption	Intent to adopt blockchain	Clohessy and Acton (2019), Delghani et al. (2022), Lustenberger et al. (2021), Webster and Gardner (2019)

The original questionnaire is presented in Appendix D. The questionnaire was divided into the following parts:

- *Part 1:* A cover letter which includes a consent or approval document and information regarding the research, information on the researcher conducting the study, the researcher's supervisors and their contact information. It also stated that the UTS Research Ethics and Integrity Policy has been followed in all stages of the research.

- *Part 2:* General information to describe the sample participants and the institutions they represented, such as gender, age, position held in their institution, and their level of familiarity with blockchain technology. The following institution data were collected: size (based on the number of students), type (private or public), current technologies in use (from the list), and the current level of blockchain adoption.

- *Part 3:* Technology factors of blockchain adoption. This section included five factors identified within the DOI theory: relative advantage (5 items), compatibility (3 items), trialability (3 items), observability (4 items) and complexity (4 items).

- *Part 4:* Organisational factors of blockchain adoption. This section included two factors identified in the TOE theory: top management support (4 items) and institutional readiness (3 items).

- *Part 5*: Environmental factors of blockchain adoption. This section included three factors identified in the TEO theory: existing regulations (3 items), government support (2 items) and peer pressure (3 items);

- *Part 6*: Quality factors of blockchain adoption. This section included two factors identified in the relevant research on quality in higher education: education quality improvements (3 items) and student employment improvements (4 items).

- *Part 7*: Barriers to blockchain adoption. This section included four factors identified in the DOI and TOE frameworks: lack of knowledge (4 items), association with finance (4 items), privacy and security concerns (4 items) and language concerns (2 items).

- *Part 8:* Adoption of blockchain, which was represented by 2 items.

6.6 Chapter Summary

This chapter presented the results of the first phase of the research which involved interviews with the decision makers holding administrative and IT positions in Saudi colleges and universities. The total sample included 10 individuals, with the limit reached at the point of qualitative data saturation (no meaningful new insights emerged from 11th interview). The interview participants discussed the current state of blockchain adoption in education and the factors which they believed were important for the blockchain adoption process in Saudi HEIs. The data analysis followed the Miles and Huberman (2019) methodology and involved qualitative data reduction, theme development, and pattern matching. In general, the respondents viewed blockchain applications in higher education positively, although they also noted its limited use at the moment. Diplomas and certificates emerged as the key area of blockchain applications in higher education. Therefore, the finalised questionnaire was adjusted specifically to this application of blockchain technology.

The second part of the analysis focused on refining the original research framework. The interviewees discussed their views regarding the factors included in the model and proposed additional factors that they believed were relevant. The analysis led to the integration of some factors into others, eliminating some redundant constructs and adding two additional factors of language concerns and association of blockchain with finance only. The refined model included 14 factors instead of 21 in the original framework. The refined framework served as the basis for quantitative instrument development and an analysis based on a large-scale survey. The next chapter presents the survey results.

7 Research PHASE2: Model Evaluation

7.1 Introduction

This chapter presents the analysis of the collected survey data. Section 7.2 provides the descriptive analysis of the data, the survey response rate and sample structure. Section 7.3 provides the preliminary data analyses to ensure good data quality and to check for possible issues with bias, normality, validity and reliability. Section 7.4 offers the results of the structure equation modelling (SEM) with the analyses covering model validation and hypotheses testing. Section 7.5 summarises the results within the formulated conceptual framework.

7.2 Descriptive Analysis

In total, 504 online survey questionnaires were submitted from the target population. To ensure good data quality, a set of exclusion criteria was applied. Specifically, the following submissions were excluded from the analysis:

1. Incomplete surveys;
2. Surveys submitted in a very short time period (a minimum reasonable time to read, comprehend, and answer the questionnaire items was set at 6 minutes as determined during the pilot test of the questionnaire);
3. Surveys containing the same responses to all items (reverse items were included in the survey to ensure that the respondents had read all the items and answered thoughtfully).

After the exclusion criteria were applied, 289 completed questionnaires were retained for analysis. Given the estimated population size of 2,000 individuals, the margin of error was 5.3% (Dattalo, 2008).

7.2.1 Sample Characteristics

The descriptive statistics of the sample includes basic information about the educational institutions where the respondents work, their positions in those institutions, and their level of blockchain knowledge.

Regarding the type of higher education institution (HEI), 260 respondents (90%) were employed in public colleges and universities and 29 respondents (10%) in private HEIs. The majority of respondents (n = 133, 46.0%) were from large size HEIs of 15,000 students or more, followed by midsize HEIs of 5,000-14,999 students (n = 87, 30.1%) and smaller HEIs with fewer than 5,000 students (n = 69, 23.9%). The results are presented in Table 34.

Table 34: Organisational Characteristics of the Sample

Institution by Type of Funding		
	n	%
Public	260	90
Private	29	10
Total	289	100
Institution by Size		
	n	%
15,000+ students	133	46.0
5,000 - 14,999 students	87	30.1
< 5,000 students	69	23.9
Total	289	100

In terms of the individual characteristics of the respondents, the majority (n = 112, 38.8%) were senior IT personnel and CTOs, followed by senior administrative personnel such as presidents, vice-presidents, deans and the members of the board (n = 91, 31.5%). The remaining respondents (n = 86, 29.8%) represented mid-level IT and administrative positions. Of the respondents, the vast majority were familiar with blockchain technology, having either good (n = 125, 43.3%) or some knowledge (n = 108, 37.4%) about it. Only a small number of respondents (n = 56, 19.4%) indicated having little to no knowledge about blockchain. The results are presented in Table 35.

Table 35: Individual Characteristics of the Sample

Respondents by Position		
	n	%
Senior IT	112	38.8
Senior Administrative	91	31.5
Other	86	29.8
Total	289	100
Knowledge of Blockchain		
	n	%
Good	125	43.3
Some	108	37.4
Little or none	56	19.4
Total	289	100

7.3 Preliminary Analysis

Provided below is the preliminary analysis of the collected data. The goal of the preliminary analysis is to ensure data integrity prior to running the inferential statistics tests. Accordingly, the preliminary analysis included: screening for missing data, general statistics of the scale items, tests of data normality assumption, outlier screening, and bias tests. Further, the data were checked for validity, internal consistency, and multicollinearity.

7.3.1 Missing Data Analysis and Scale Items' Statistics

The first step in the analysis was to check for the missing items and report the means and the standard deviations of the scale items. Appendix E shows the SPSS results of the descriptive statistics analysis for all 61 scale items. It can be seen that all items were represented by 289 responses. Given that the total number of respondents was 289, there was no indication of missing data.

The means and standard deviations of all scale items are also reported in Appendix E. It can be observed that all response means were above 3, which represents the middle value of the 7-point Likert-scale. Therefore, on average, the respondents treated all items positively. A measure of standard error of the sample mean (Altman & Bland, 2005) was applied for all items to test for the degree of variability. The values ranged between 6.8% and 11.2%, indicating relatively low levels of variation in the data.

7.3.2 Data Normality

Normality refers to the tendency of the collected data to match the normal distribution (Hair, Black, Babin, & Anderson, 2018; Johnson & Wichern, 2007). Testing for normality determines whether the data should be analysed with parametric or non-parametric tests (Kline, 2015). Whereas large samples are typically believed to demonstrate the normal distribution shape in general, certain items may still exhibit deviations due to outliers. The normality tests for the collected data in this study were performed by measuring the skewness and kurtosis levels of the scale items. Several guidelines exist regarding the admissible values of skewness and kurtosis. Some authors suggest that both skewness and kurtosis should be within ± 2 value to perform normal univariate distribution tests (George & Mallery, 2010). Others propose looser acceptable values for kurtosis at ± 7 (Byrne, 2010; Hair, Black, Babin, & Anderson, 2018). Yet others argued that due to the robustness of structural equation modelling tests, data should be considered normal for the purpose of analysis if its skewness is within ±3 range and kurtosis is within ±10 range (Brown, 2006; Kline, 2015).

The normality tests performed for the scale items used in this research are reported in Appendix E. The results demonstrated a skewness range between -1.338 and 0.442 and kurtosis range between -1.148 and 2.454. As such, the results were very close to the most stringent normality ranges suggested in the literature, as discussed above. Therefore, the collected data were deemed normal for the purpose of this research and analysis.

7.3.3 Outlier Screening

Outliers are data points that lie way outside of the main data pattern (Osborne & Overbay, 2004). Outliers can be natural: that is, a small percent of unusually different observations are expected in a large population. However, in some cases, outliers can result from measurement or data collection errors. Both types of outliers may distort the data and affect the statistical analyses results; however, non-natural outliers are more dangerous since they do not represent real observations. For this reason, this study screened for outliers in the collected dataset. The screening was performed using the z-score technique where scale items are transformed into standardised scores. The obtained coefficients show how many standard deviations a datapoint is above or below the mean. A rule of thumb is that outliers lie above the absolute value of a standardised score of 3.29 which cuts off 0.1% of all data points (Martin & Bridgmon, 2012; Tabachnik & Fidell, 2018).

Appendix F shows the z-scores for all scale items in the dataset. It can be seen that several variables possessed data points that could be considered outliers. However, the maximum number of outliers for a single item was 7 (QF_QI_1), which represented only 2.4% of the total observations. According to Tabachnik and Fidell (2018), removing outliers is recommended only when there is strong evidence that they are beyond what could normally be observed in a sample data. The presence of 2.4% or fewer responses containing unusual data can be interpreted as normal. Since the study used a 7-point Likert scale for answers, it is not unusual that a few respondents took either very positive or very negative perspectives on most of the issues. In fact, this could be evident through the consistent presence of some respondents across most of the outlier scores. Specifically, respondents 2, 3, 5, 98 and 252 consistently provided very negative responses to relative advantage, trialability and quality of service whereas the vast majority provided positive responses. Therefore, to preserve the integrity of the data, it was decided to keep all responses, including the outliers, for the data analysis.

7.3.4 Non-Response Bias Tests

With 289 valid submissions out of 504, the non-response rate was about 42.7%. This raised concerns about possible non-response bias. According to Coderre et al. (2004), non-response bias represents the potential differences between the population representatives who respond to surveys and those who do not. Accordingly, if such differences exist, a generalisation of the survey results onto the population becomes problematic (Werner, Praxedes, & Kim, 2007). A common technique to check for non-response bias is described by Armstrong and Overton (1977) where partial respondents and later survey respondents are treated as proxies to non-participants and their responses are compared to the early survey participants. A series of t-tests were conducted to check for potential differences in scale item responses between 30 early survey participants and 30 late survey participants. Because no statistically significant differences were observed, it was concluded that the collected data were not prone to non-response bias.

7.3.5 Common Method Bias Tests

Whereas the non-response bias test deals with potential participation issues, the common method bias test analyses possible data distortions due to data collection methods. In the literature, common method bias is defined as variance stemming from the procedures rather than the actual variables that the research measures should represent (Lowry & Gaskin, 2014; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). In other words, the choice of methods may inflate the strength of the actual relationships between the variables in a study. To examine the collected data for the common method bias, Harman's test was used with an unrotated factor analysis for all variable items and a cut-off point of 50% for a single factor (Podsakoff et al., 2003). The SPSS analysis produced 11 factors with the largest one accounting for 32.457% variance (Appendix G), well below the established cut-off point. Therefore, it was concluded that common method bias was not an issue with the collected survey data.

7.3.6 Factor Analyses

Factor analysis is an important step in research because it validates the instrument used for quantitative data collection and determines how well the survey items align with the formulated constructs. The two commonly used methods to do this are exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) (Kline, 2015). EFA seeks to determine the data structure and a maximum amount of variance in the factors whereas CFA seeks to validate the existing models to ensure they fit with the existing study context (Fabrigar & Wegener, 2012; Widaman, 2012). As such, EFA is considered more appropriate in the early research stages or for testing the newly developed instruments whereas CFA is better suited for previously confirmed measures and models.

While survey data collection in this study relied mostly on the previously developed scales, the instrument itself was translated into Arabic which arguably makes it "new". Moreover, the model in this study includes several items in the quality of education construct which have not been applied before. For this reason, both EFA and CFA were used. There are also recommendations in the literature in support of this approach. To enhance the quality of factor analysis, some authors recommend applying EFA for model specification and later apply CFA to cross-validate the model (Cabrera-Nguyen, 2010; Taherdoost, Sahibuddin, & Jalaliyoon, 2014; Worthington & Whittaker, 2006). This study followed those recommendations.

Factor analyses were performed for five multi-variable dimensions in the conceptual model: technology factors (5 variables), organisational factors (2 variables), environmental factors (3 variables), quality factors (2 variables), and barriers to adoption (4 variables). The EFA were performed using principal axis factoring extraction with a promax rotation which assumes that the items are correlated (Tabachnik & Fidell, 2018). The Kayser-Meyer-Olkin (KMO) test was performed to check the data fit for factor analysis aiming for values 0.7 and above (Kline, 2015). For individual items, communality scores and cross-loadings were used to determine their inclusion in the final model. Acceptable communality scores were considered above 0.4 (Osborne, Costello, & Kellow, 2008). Acceptable cross-loadings were considered in the range below/above ± 0.2 for the items loading on more than one factor (Ding & Shen, 2017). Following Nunnally (1978) and Hair et al. (2018), individual item loadings onto their corresponding factor should be ≥ 0.5 while the average of all item loadings onto their corresponding factor should be ≥ 0.7. Finally, the internal consistency of the data for each construct was measured with Cronbach's alpha and item-rest correlation with acceptable values ≥ 0.7 and ≥ 0.3 respectively (Nunnally, 1978).

A CFA was performed after the EFA for each dimension in the model. According to Kline (2015), for models exceeding 200 cases, the chi-square values could be misleading. Therefore, the model fit was estimated based on the number of additional parameters such as comparative fit index (CFI, ≥0.9), normality fit index (NFI, ≥0.9), Tucker-Lewis index (TLI, ≥0.9), root mean square error of approximation (RMSEA, ≤0.1), and standardized root mean square residual (SRMR, ≤0.1) (Hair, Black, Babin, & Anderson, 2018; Kline, 2015; Williams, Hartman, & Cavazotte, 2010). The tests for convergent and discriminant validity were performed using average variance extracted (AVE). For convergent validity, the acceptable AVE score was ≥0.5 whereas for discriminant validity, the square root AVE scores had to be below the constructs' cross-correlations (Fornell & Larcker, 1981; Hair, Black, Babin, & Anderson, 2018).

7.3.6.1 Technology Dimension

The technology dimension was represented by five factors: relative advantage, compatibility, trialability, observability, and complexity. The results of the EFA are shown in Table 36. The rotation converged in 6 iterations onto 5 constructs with an acceptable KMO = 0.891 and cumulative 78.376% variance. All communality scores were above the established 0.4 threshold. Two potentially problematic items were observed with cross-loadings onto two factors: TF_COM_1 and TF_TRI_3. However, only TF_COM_1 showed a cross-loading within the ±0.2 range which made it a candidate for elimination. Moreover, its loading power on both factors was relatively weak (.451 and .432 respectively). Therefore, it was decided to drop TF_COM_1 item from further analysis to avoid discriminant validity issues. The EFA analysis without the dropped item showed no possible issues with factor loadings or relative parameters (Table 37).

Table 36: Results of the First EFA for Technology Dimension Variables

Pattern Matrix[a]

Items	Communality Score	Component 1	2	3	4	5
TF_RA_1	.753	.890				
TF_RA_2	.830	.935				
TF_RA_3	.757	.897				
TF_RA_4	.747	.765				
TF_RA_5	.721	.743				
TF_COM_1	.672	.451			.432	
TF_COM_2	.847				.857	
TF_COM_3	.844				.954	
TF_COM_4	.675				.687	
TF_TRI_1	.733					.745
TF_TRI_2	.841					.864
TF_TRI_3	.745				.411	.674
TF_OB_1	.876		.950			
TF_OB_2	.884		.995			
TF_OB_3	.748		.837			
TF_OB_4	.659		.679			
TF_COX_1	.748			.881		
TF_COX_2	.838			.902		
TF_COX_3	.881			.927		
TF_COX_4	.876			.910		

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization. KMO = 0.891, $p < .01$
a. Rotation converged in 6 iterations. Suppressed values below 0.4

Table 37: Results of Final EFA for Technology Dimension Constructs

Items	Communality Score	1	2	3	4	5
	Pattern Matrix[a]					
		Component				
TF_RA_1	.756	.826				
TF_RA_2	.827	.883				
TF_RA_3	.765	.878				
TF_RA_4	.770	.778				
TF_RA_5	.746	.756				
TF_COM_2	.839				.820	
TF_COM_3	.870				.940	
TF_COM_4	.644				.796	
TF_TRI_1	.812					.887
TF_TRI_2	.838					.884
TF_TRI_3	.712					.764
TF_OB_1	.863		.932			
TF_OB_2	.882		.987			
TF_OB_3	.756		.840			
TF_OB_4	.681		.703			
TF_COX_1	.748			.882		
TF_COX_2	.839			.902		
TF_COX_3	.880			.928		
TF_COX_4	.877			.911		

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization. KMO = 0.884, $p < .01$
a. Rotation converged in 6 iterations. Suppressed values below 0.4

The maintained data were analysed for internal consistency. All five constructs demonstrated high reliability scores for both individual items (CITC) and construct variables (Cronbach's alpha). Therefore, all items and constructs were retained for the CFA. Table 38 provides a summary of the reliability analyses for all retained technology dimension items and constructs.

Table 38: Reliability Analysis of the Technology Dimension Items

Item	Wording	Mean	St.D	CITC	Cronbach's alpha
	Relative Advantage				
TF_RA_1	Blockchain will speed up the university certificate process.	5.60	1.426	.756	.917
TF_RA_2	Blockchain will make the certificate issue process easier.	5.74	1.338	.836	
TF_RA_3	Blockchain will reduce the costs of certificate issue.	5.70	1.260	.782	
TF_RA_4	Blockchain will make certificates more secure.	5.93	1.226	.790	
TF_RA_5	Blockchain will streamline certificate verification.	5.90	1.160	.770	
	Compatibility				
TF_COM_2	Blockchain is suitable for issuing university certificates.	5.52	1.259	.769	.861
TF_COM_3	Blockchain is suitable for university certificate verification.	5.64	1.199	.796	
TF_COM_4	Blockchain is compatible with certificate issue processes.	5.29	1.327	.656	
	Trialability				
TF_TRI_1	It will be possible to set a trial for blockchain-based certificate issue	5.47	1.264	.679	.841
TF_TRI_2	Out school would prefer to trial and test blockchain before full scale implementation.	5.51	1.267	.794	
TF_TRI_3	A successful trial for blockchain-based certificate issue and verification will be key to its implementation.	5.81	1.162	.652	
	Observability				
TF_OB_1	There is sufficient information about blockchain applications for education.	4.19	1.815	.848	.909
TF_OB_2	There is sufficient information about blockchain application for education certificates.	4.33	1.804	.858	
TF_OB_3	We are aware of blockchain use for university certificates.	4.46	1.746	.778	
TF_OB_4	Blockchain has so far demonstrated benefits for education institutions.	4.97	1.481	.708	
	Complexity				
TF_COX_1	Blockchain is conceptually difficult to understand.	3.86	1.695	.737	.927
TF_COX_2	Blockchain benefits for school certificates are hard to exploit.	3.61	1.663	.840	
TF_COX_3	Blockchain technology is difficult to use for school certificates.	3.41	1.654	.879	
TF_COX_4	It is difficult to master blockchain applications for school certificates.	3.38	1.688	.869	

The results of the CFA for the retained variables and items are presented in Table 39. The model showed a good fit (CFI=0.939, NFI=0.911, TLI=0.927, RMSEA=0.082, SRMR=0.079). All standardised regression coefficients were above 0.7 which represents strong loadings. The convergent and discriminant validity of the data were estimated based on the AVE scores. The AVE was estimated at 0.727, above the 0.5 threshold. Therefore, convergent validity was established. Further, the AVE square root estimate of 0.853 was above the highest correlation of the variables (r = 0.800, relative advantage – compatibility). Therefore, discriminant validity was also established.

Table 39: CFA for Technology Dimension Constructs and Items

Item	**Standardised Regression Weights**	**AVE**	$\sqrt{\textbf{AVE}}$	**Highest Construct Correlation**	**Model Fit**
TF_RA_1	.827				
TF_RA_2	.829				
TF_RA_3	.830				
TF_RA_4	.854				
TF_RA_5	.734				
TF_COM_2	.759				
TF_COM_3	.881				
TF_COM_4	.873				CFI = 0.939
TF_TRI_1	.789				TLI = 0.927
TF_TRI_2	.871	0.727	0.853	0.800	NFI = 0.911
TF_TRI_3	.752				RMSEA = 0.085//
TF_OB_1	.900				SRMR = 0.079
TF_OB_2	.930				
TF_OB_3	.774				
TF_OB_4	.737				
TF_COX_1	.937				
TF_COX_2	.953				
TF_COX_3	.849				
TF_COX_4	.786				

7.3.6.2 Organisation Dimension

The organisation dimension was represented by two factors: top management support (TMS) and institution readiness (IR). The EFA results are presented in Table 40. The rotation converged in 3 iterations onto 2 constructs with an acceptable KMO = .914 and cumulative 78.272% variance. All communality scores were above the established 0.4 threshold. Two potentially problematic items were observed: OF_IR_1 and OF_IR_5 both of which cross-loaded significantly onto two factors. Because the cross-loading difference for both items fell into the ±0.2 range, these items were dropped from further analysis to avoid discriminant validity issues. The final EFA run without the deleted items is shown in Table 41. No issues with loadings or relevant parameters were present.

Table 40: Results of First EFA for Organisation Dimension

Items	Communality Score	Component 1	Component 2
OF_TMS_1	.700	.793	
OF_TMS_2	.873	.889	
OF_TMS_3	.760	.750	
OF_TMS_4	.857	.840	
OF_IR_1	.653	.489	
OF_IR_2	.790		.875
OF_IR_3	.836		.804
OF_IR_4	.826		.803
OF_IR_5	.746	.493	.512

Pattern Matrix[a]

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization, KMO = .914, $p < .001$
a. Rotation converged in 3 iterations. Suppressed values below 0.4

Table 41: Results of the Final EFA for Organisation Dimension Variables

Items	Communality Score	Component 1	Component 2
OF_TMS_1	.714	.845	
OF_TMS_2	.887	.941	
OF_TMS_3	.774	.875	
OF_TMS_4	.852	.922	
OF_IR_2	.805		.895
OF_IR_3	.850		.919
OF_IR_4	.823		.905

Pattern Matrix[a]

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization, KMO = .873, $p < .001$
a. Rotation converged in 3 iterations. Suppressed values below 0.4

The remaining items and constructs were analysed for internal consistency. Both top management support and institutional readiness constructs demonstrated high reliability scores for both individual items (CITC) and construct variables (Cronbach's alpha). Therefore, all remaining items and constructs were retained for the CFA. Table 42 provides a summary of the reliability analyses for all retained organisation dimension items and constructs.

Table 42: Reliability Analysis for Organisation Dimension Constructs and Items

Item	Wording	Mean	St.D	CITC	Cronbach's alpha
	Top Management Support				
OF_TMS_1	Our top management provides timely and sufficient information about new technology implementation in our institution.	5.02	1.610	.724	.915
OF_TMS_2	Our top management provides strong leadership when it comes to technology adoption.	5.34	1.420	.881	
OF_TMS_3	Our top management is likely to consider the adoption of blockchain for university certificates as strategically important.	5.23	1.404	.784	
OF_TMS_4	Our top management supports new technology implementation for the institution.	5.52	1.326	.853	
	Institutional Readiness				
OF_IR_2	Our institution has sufficient financial resources to integrate blockchain for certificates.	5.31	1.425	.750	.895
OF_IR_3	Our institution has sufficient technical capacity for blockchain adoption.	5.22	1.546	.831	
OF_IR_4	Our institution has sufficient human resource capacity to implement blockchain technology for certificates.	5.11	1.595	.801	

The results of the CFA for the retained variables and items are presented in Table 43. The model showed a good fit (CFI=0.939, NFI=0.911, TLI=0.927, RMSEA=0.082, SRMR=0.079). All standardised regression coefficients were above 0.7 which represents strong loadings. The convergent and discriminant validity of the data were estimated based on the AVE scores. The AVE was estimated at 0.679, above the 0.5 threshold. Therefore, convergent validity was established. Further, the AVE square root estimate of 0.824 was above the correlation of the variables (r = 0.751). Therefore, discriminant validity was also established.

Table 43: CFA for Organisation Dimension Constructs and Items

Item	**Standardised Regression Weights**	**AVE**	$\sqrt{\text{AVE}}$	**Construct Correlation**	**Model Fit**
OF_TMS_1	.938	0.679	0.824	0.751	CFI = 0.983 TLI = 0.973 NFI = 0.975 RMSEA = 0.086 SRMR = 0.080
OF_TMS_2	.852				
OF_TMS_3	.897				
OF_TMS_4	.755				
OF_IR_2	.835				
OF_IR_3	.919				
OF_IR_4	.821				

7.3.6.3 Environmental Factors Dimension

The external factors dimension was represented by three factors: existing regulations (ER), government support (GS), and peer pressure (PP). The EFA results are presented in Table 44. The rotation converged in 5 iterations onto 3 constructs with an acceptable KMO = .824 and cumulative 84.846% variance. All communality scores were above the established 0.4 threshold. No cross-loading issues were observed for the items. Therefore, all items and constructs were analysed for internal consistency.

All three constructs in the dimension demonstrated high reliability scores for both individual items (CITC) and construct variables (Cronbach's alpha). Therefore, all items and constructs were retained for the CFA. Table 45 provides a summary of the reliability analyses for all retained external factors dimension items and constructs.

Table 44: EFA for the Environmental Factors Dimension

Pattern Matrix[a]

Items	Communality Scores	Component		
		1	2	3
EF_ERS_1	.880	.965		
EF_ERS_2	.915	.968		
EF_ERS_3	.734	.791		
EF_GS_1	.828			.798
EF_GS_2	.880			.972
EF_PP_1	.843		.897	
EF_PP_2	.864		.936	
EF_PP_3	.843		.908	

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization. KMO = .824, $p < .001$
a. Rotation converged in 5 iterations. Suppressed values below 0.4

Table 45: Reliability Analysis for the Environmental Factors Dimension Constructs and Items

Item	Wording	Mean	St.D	CITC	Cronbach's alpha
	Existing Regulations				
EF_ERS_1	The Ministry of Education dictates to us what technologies to adopt.	4.71	1.654	.838	
EF_ERS_2	The Ministry of Education dictates to us what technologies to use.	4.71	1.631	.886	.906
EF_ERS_3	Blockchain is tightly regulated for organizations in Saudi Arabia.	4.48	1.646	.719	
	Government Support				
EF_GS_1	Our institution receives subsidies for new technology implementation.	5.03	1.408	.661	.796
EF_GS_2	The Saudi government promotes new technology applications in education institutions like ours.	5.49	1.315	.661	
	Peer Pressure				
EF_PP_1	We are willing to use blockchain for certificates if we see that other institutions use it.	5.43	1.400	.819	
EF_PP_2	We will consider implementing blockchain for certificates if it becomes popular.	5.45	1.359	.833	.911
EF_PP_3	We will consider implementing blockchain for certificates if we see that other institutions benefit from doing so.	5.54	1.304	.817	

The results of the CFA for the retained variables and items are presented in Table 46. The model showed a good fit (CFI=0.972, NFI=0.961, TLI=0.960, RMSEA=0.089, SRMR=0.081). All standardised regression coefficients were above 0.7 which represents strong loadings. The convergent and discriminant validity of the data were estimated based on the AVE scores. The AVE was estimated at 0.823, above the 0.5 threshold. Therefore, convergent validity was established. Further, the AVE square root estimate of 0.907 was above the highest correlation of the variables (r = 0.633, existing regulations – government support). Therefore, discriminant validity was also established.

Table 46: CFA for the Environmental Factors Dimension Constructs and Items

Item	Standardised Regression Weights	AVE	$\sqrt{AVE}$	Highest Construct Correlation	Model Fit
EF_ERS_1	.793	0.823	0.907	.633	CFI=0.972
EF_ERS_2	.974				NFI=0.961
EF_ERS_3	.900				
EF_GS_1	.810				TLI=0.960
EF_GS_2	.816				
EF_PP_1	.884				RMSEA=0.089
EF_PP_2	.892				SRMR=0.081
EF_PP_3	.863				

7.3.6.4 Quality Factors

The quality factors dimension was represented by two factors: education quality improvements (QI) and employment improvements (EI). The EFA results are presented in Table 47. The rotation converged in 3 iterations onto 2 constructs with an acceptable KMO = .879 and cumulative 83.246% variance. All communality scores were above the established 0.4 threshold. No cross-loading effects were observed for the items; therefore, all items and constructs were retained.

Table 47: EFA for the Quality Factors Dimension

Pattern Matrix[a]			
Items	Communality Score	Component	
		1	2
QF_QI_1	.870	.928	
QF_QI_2	.911	1.035	
QF_QI_3	.769	.708	
QF_QE_1	.735		.618
QF_QE_2	.868		1.025
QF_QE_3	.902		.970

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization, KMO = .879, $p < .001$
a. Rotation converged in 3 iterations. Suppressed values below 0.4

Both education quality improvements and employment improvements constructs demonstrated high reliability scores for both individual items (CITC) and construct variables (Cronbach's alpha). Therefore, all remaining items and constructs were retained for the CFA. Table 48 provides a summary of the reliability analyses for all retained organisation dimension items and constructs.

Table 48: Reliability Analysis for Constructs and Items in the Quality Factors Dimension

Item	Wording	Mean	St.D	CITC	Cronbach's alpha
	Education Quality Improvements				
QF_QI_1	Blockchain use for certificates will improve the quality of education.	5.57	1.342	.836	
QF_QI_2	Blockchain use will improve the quality of school administration.	5.69	1.258	.864	.908
QF_QI_3	Blockchain use for certificates aligns well with our school's mission and goals.	5.65	1.255	.754	
	Employment Improvements				
QF_QE_1	Our school considers new technologies as a way to reduce student unemployment after graduation.	5.26	1.438	.812	
QF_QE_2	Blockchain technology has the potential to reduce student unemployment.	5.20	1.440	.885	.917
QF_QE_3	Blockchain technology will streamline the employment process for students after graduation.	5.41	1.372	.791	

The results of the CFA for the retained matrices initially demonstrated a poor model fit (CFI=0.962, NFI=0.934, TLI=0.956, RMSEA=0.139, SRMR=0.111). A further analysis of the standardised residual covariances matrix showed that QF_QE_3 item was problematic and a potential source of construct validity. After removing this item from the model, the CFA improved to an acceptable level (CFI=0.984, NFI=0.967, TLI=0.980, RMSEA=0.089, SRMR=0.091). All standardised regression coefficients were above 0.7 which represents strong loadings. The convergent and discriminant validity of the data were estimated based on the AVE scores. The AVE was estimated at 0.796, above the 0.5 threshold. Therefore, the convergent validity was established. Further, the AVE square root estimate of 0.892 was above the correlation of the variables (r = 0.733). Therefore, discriminant validity was also established. The results of the analysis are shown in Table 49.

Table 49: CFA for the Quality Dimension Constructs and Items

Item	Standardised Regression Weights	AVE	$\sqrt{AVE}$	Highest Construct Correlation	Model Fit
QF_QI_1	.892	.796	.892	.733	CFI=0.984
QF_QI_2	.954				NFI=0.967
QF_QI_3	.874				TLI=0.980
QF_EI_1	.786				RMSEA=0.089
QF_EI_2	.828				SRMR=0.091
QF_EI_3	.871				

7.3.6.5 Barriers to Adoption

The barriers to adoption dimension was represented by four factors: lack of knowledge, association with finance, privacy and security concerns, and language concerns. The results of the EFA are shown in Table 50. The rotation converged in 5 iterations onto 4 constructs with an acceptable KMO = 0.811 and cumulative 84.500% variance. All communality scores were above the established 0.4 threshold. No cross-loadings for the items were observed. Therefore, all items and constructs were retained for further analysis.

Table 50: EFA for the Barriers to Adoption Dimension

Pattern Matrix[a]

Items	Communality Score	Component 1	2	3	4
BF_LOK_1	.911	.947			
BF_LOK_2	.927	.965			
BF_LOK_3	.922	.947			
BF_LOK_4	.888	.947			
BF_AWF_1	.666			.803	
BF_AWF_2	.801			.828	
BF_AWF_3	.748			.858	
BF_AWF_4	.672			.729	
BF_PAS_1	.880		.938		
BF_PAS_2	.914		.964		
BF_PAS_3	.834		.898		
BF_PAS_4	.827		.903		
BF_LC_1	.921				.942
BF_LC_2	.918				.932

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization. KMO = 0.811, $p < .01$

a. Rotation converged in 5 iterations. Suppressed values below 0.4

The maintained data were analysed for internal consistency. All four constructs demonstrated high reliability scores for both individual items (CITC) and construct variables (Cronbach’s alpha). Therefore, all items and constructs were retained for the CFA. Table 51 provides a summary of the reliability analyses for all barriers to adoption dimension items and constructs.

Table 51: Reliability Analysis for the Barriers to Adoption Constructs and Items

Item	Wording	Mean	St.D	CITC	Cronbach's alpha
	Lack of Knowledge				
BF_LOK_1	We still know little about blockchain applications for university certificates.	5.13	1.450	.918	.968
BF_LOK_2	We still know little about the technical implementation of blockchain for university certificates.	5.13	1.472	.933	
BF_LOK_3	We still know little about the success of blockchain for university certificates.	5.10	1.497	.927	
BF_LOK_4	We still know little about how to integrate blockchain with the certificate issue/verification process.	5.10	1.493	.898	
	Association with Finance				
BF_AWF_1	Blockchain is primarily a financial instrument.	4.79	1.559	.552	.819
BF_AWF_2	Blockchain so far has been used in finance only.	4.25	1.740	.733	
BF_AWF_3	Blockchain is designed for financial transactions primarily.	4.83	1.444	.679	
BF_AWF_4	There has been little application of blockchain beyond the financial industry.	4.38	1.673	.615	
	Privacy and Security Concerns				
BF_PAS_1	We do not feel secure about sharing institution data on a blockchain platform.	3.50	1.803	.894	.948
BF_PAS_2	We do not feel secure about sharing student data on a blockchain platform.	3.57	1.809	.923	
BF_PAS_3	We are not sure about the policies and regulations regarding data on a blockchain platform.	3.89	1.911	.845	
BF_PAS_4	Student data on blockchain is a potential privacy concern.	3.83	1.896	.841	
	Language Concerns				
BF_LC_1	There is little general information about blockchain for certificates in Arabic.	5.11	1.628	.880	.935
BF_LC_2	There is little technical information about blockchain in Arabic.	5.34	1.517	.880	

The results of the CFA for the retained variables and items are presented in Table 52. The model showed a good fit (CFI=0.966, NFI=0.950, TLI=0.954, RMSEA=0.082, SRMR=0.077). All standardised regression coefficients were above 0.7 which represents strong loadings. The convergent and discriminant validity of the data were estimated based on the AVE scores. The AVE was estimated at 0.815, above the 0.5 threshold. Therefore, convergent validity was established. Further, the AVE square root estimate of 0.903 was above the highest correlation of the variables (r = 0.445, lack of knowledge – language concerns). Therefore, discriminant validity was also established.

Table 52: CFA for Barriers to Adoption Dimension and Items

Item	Standardised Regression Weights	AVE	$\sqrt{AVE}$	Highest Construct Correlation	Model Fit
BF_LOK_1	.926	0.815	0.903	0.445	CFI=0.966 NFI=0.950 TLI=0.954 RMSEA=0.082 SRMR=0.077
BF_LOK_2	.948				
BF_LOK_3	.935				
BF_LOK_4	.933				
BF_AWF_1	.734				
BF_AWF_2	.605				
BF_AWF_3	.944				
BF_AWF_4	.520				
BF_PAS_1	.854				
BF_PAS_2	.854				
BF_PAS_3	.971				
BF_PAS_4	.944				
BF_LC_1	.953				
BF_LC_2	.923				

7.3.6.6 Blockchain Adoption

Since the blockchain adoption intent dimension was represented by a single construct, a reliability analysis only was performed on the data (Table 53). The data demonstrated high levels of internal consistency for both individual items as measured by CITC and the construct as measured by the Cronbach's alpha. Therefore, all items were retained for structural equation modelling analysis.

Table 53: Reliability Analysis for the Adoption Intent Dimension

Item	Wording	Mean	St.D	CITC	Cronbach's alpha
	Blockchain Adoption Intent				
ADI_1	Our institution is considering blockchain adoption for school certificates.	4.39	1.640	.690	.871
ADI_2	Our university is willing to adopt blockchain for school certificates.	4.80	1.399	.837	
ADI_3	Our institution will likely deploy blockchain for school certificates in the nearby future.	5.03	1.419	.751	

7.3.7 Multicollinearity Test

The final step in the preliminary analysis of the collected quantitative data was multicollinearity analysis to identify potential issues with statistical significance of independent constructs due to the high correlations among them. As recommended by Hair et al. (2018) and Pallant (2010), tolerance levels ≥0.1 and VIF levels below 10 were taken as thresholds. Table 54 shows the results of a multicollinearity test performed on the 16 refined independent variables explored in the study. With the lowest tolerance factor of 0.314 and the highest VIF of 3.182 for the relative advantage factor, all refined constructs demonstrated acceptable levels in terms of multicollinearity.

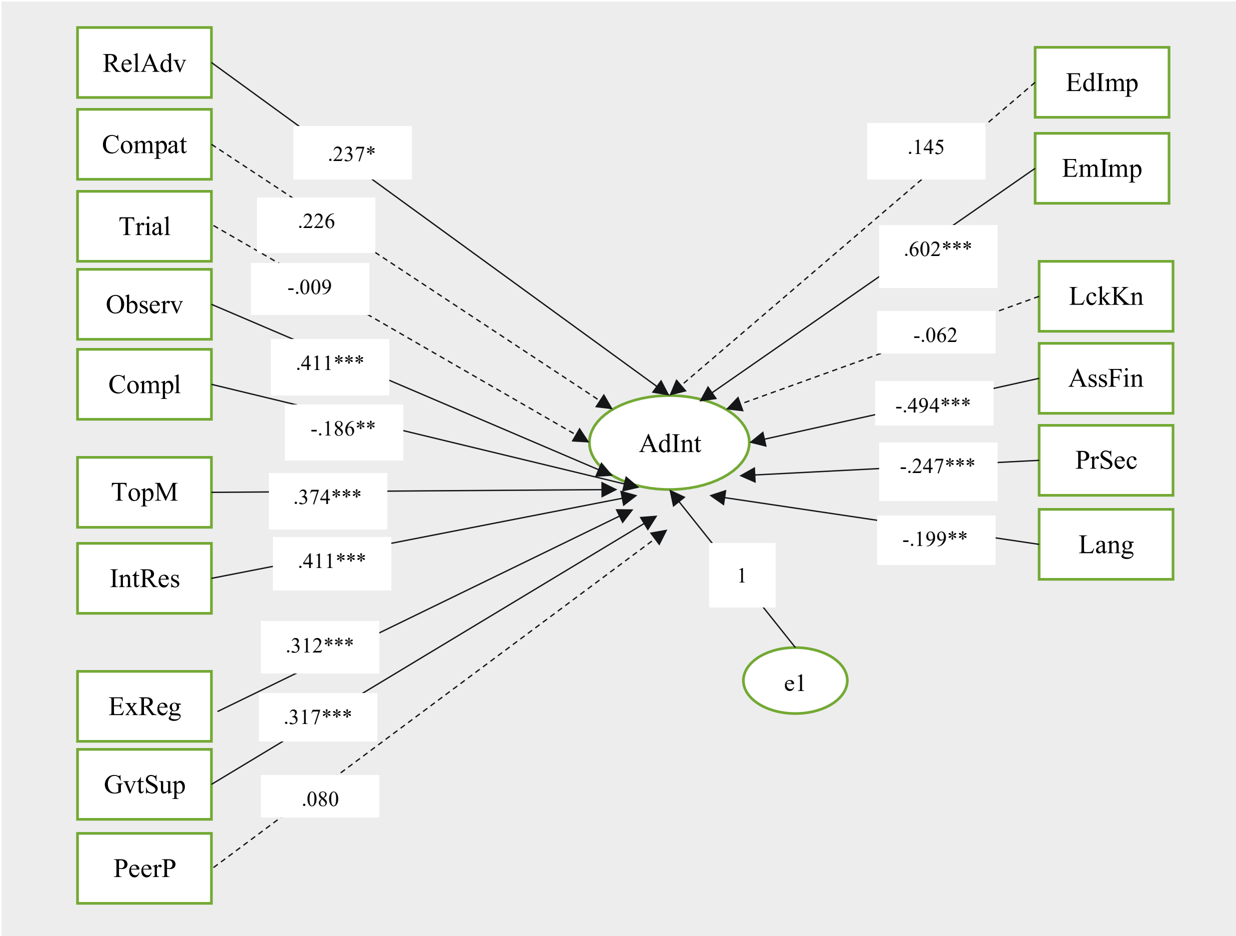
Table 54: Multicollinearity Analysis of Independent Study Constructs

	Tolerance	**VIF**
Language Concerns	0.695	1.439
Lack of Knowledge	0.642	1.558
Peer Pressure	0.601	1.663
Complexity	0.579	1.726
Association with Finance	0.550	1.817
Observability	0.503	1.986
Government Support	0.459	2.180
Existing Regulations	0.457	2.190
Privacy and Security	0.456	2.193
Internal Resources	0.422	2.368
Trialability	0.413	2.422
Top Management Support	0.373	2.683
Education Quality	0.358	2.793
Compatibility	0.339	2.952
Employment Quality	0.335	2.982
Relative Advantage	0.314	3.182

7.4 Hypothesis Testing

The final model that included 5 dimensions represented by 16 independent factors and the dependent variable adoption intent was tested for direct relationships. The observed paths are displayed in Figure 26.

Figure 26: Path Analysis of the Study Model



*p<.05; **p<.01; ***p<.001; dashed line indicates no significant relationship

Variables:

RelAdv	Relative Advantage
Compat	Compatibility
Trial	Trialability
Observ	Observability
Compl	Complexity
TopM	Top Management Support
IntRes	Internal Resources
ExReg	External Regulations
GvtSup	Government Support
PeerP	Peer Pressure
EdImp	Education Administration Improvements
EmImp	Employment Improvements
LckKn	Lack of Knowledge
AssFin	Association with Finance Only
PrSec	Privacy/Security Concerns
Lang	Language Concerns
AdInt	Intention to Adopt
e1	Error Factor

7.4.1 Technology Factors

The effect of the technology dimension variables on adoption is visualised in Figure 27: Amos Results for Technology Factors. The model for technology dimension was significant ($R^2 = .349$, $p < .001$). Of the five factors in the technology dimension, statistically significant relationships were observed for three (Table 55). The strongest relationship was demonstrated by observability ($\beta = .411$, $p < .001$), followed by relative advantage ($\beta = .237$, $p = .043$) and complexity ($\beta = -.186$, $p = .027$). Two factors did not demonstrate statistically significant relationships: trialability ($\beta = .226$, $p = .094$) and compatibility ($\beta = -.009$, $p = .863$).

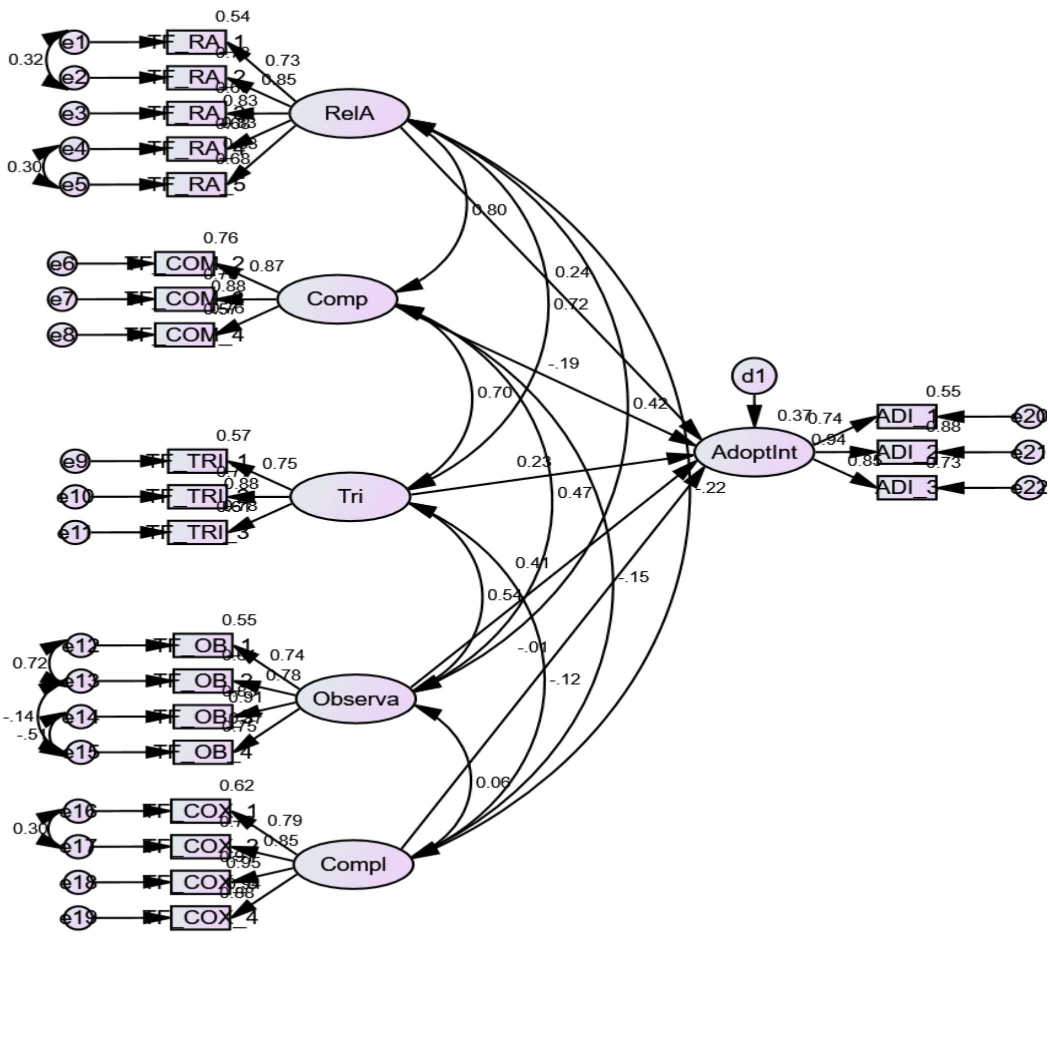


Figure 27: Amos Results for Technology Factors

Table 55: Hypothesis Testing for the Technology Dimension Variables

Relationship	Standardised Regression	S.E.	t-value	P	Hypothesis Confirmed?
H1a: Relative Advantage -> Adoption Intent	.237	.143	2.023	.043	Yes
H1b: Complexity -> Adoption Intent	-.186	.128	-1.658	.027	Yes
H1c: Trialability -> Adoption Intent	.226	.131	2.257	.094	No
H1d: Observability -> Adoption Intent	.411	.069	5.616	<.001	Yes
H1e: Compatibility -> Adoption Intent	-.009	.044	-0.172	.863	No
$R^2 = .349, p < .001$					

7.4.2 Organisational Factors

The results for the organisational factor dimension are displayed in Figure 28.

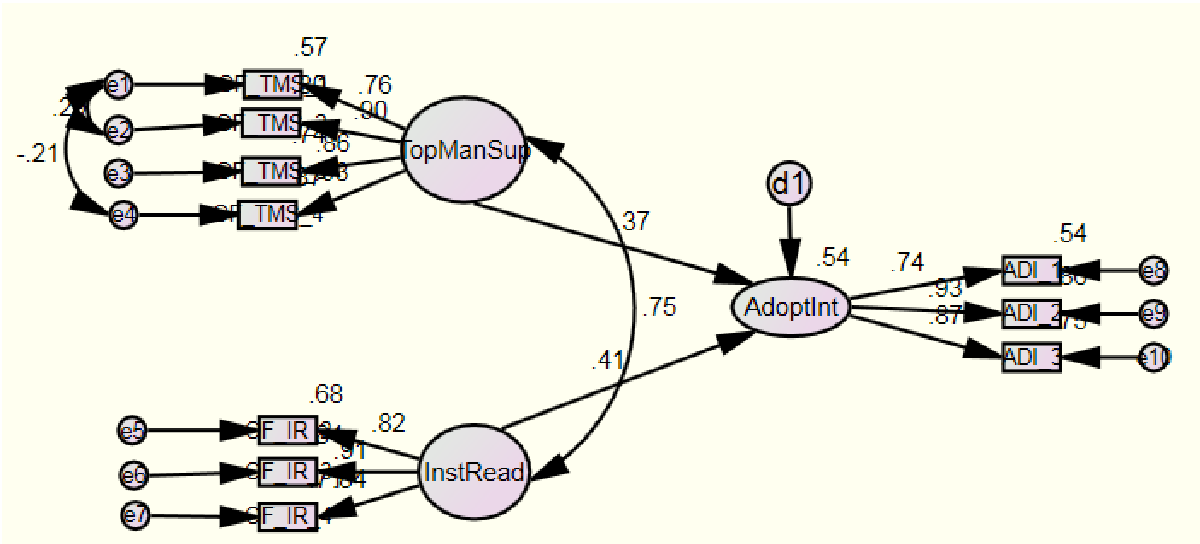


Figure 28: Amos Results for Organisational Factors

Both factors from the organisational factors dimension demonstrated positive, statistically significant relationships to adoption intent: top management support ($\beta = 0.374, p < .001$) and institutional readiness ($\beta = .411, p < .001$). The results are demonstrated in Table 56.

Table 56: Hypotheses Testing for the Organisation Dimension Variables

Relationship	Standardised Regression	S.E.	t-value	P	Hypothesis Confirmed?
H2a: Top Management Support -> Adoption Intent	.374	.079	4.609	<.001	Yes
H2b: Institutional Readiness -> Adoption Intent	.411	.079	4.964	<.001	Yes
$R^2 = .367, p < .001$					

7.4.3 Environmental Factors

The output from the Amos model for the environmental factors variables is presented in Figure 29.

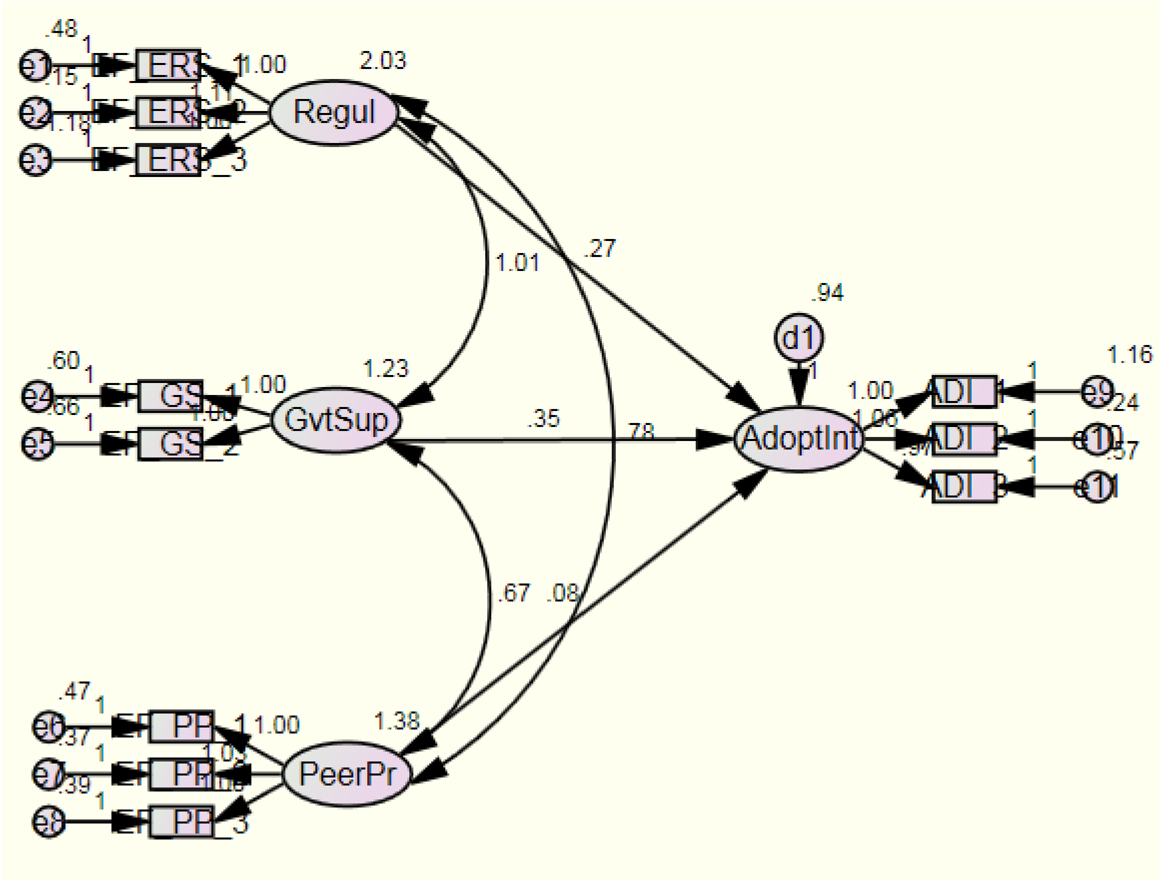


Figure 29: Amos Results for Environmental Factors

Two of the three external environment factors showed statistically significant relationships to adoption intent: existing regulations (β = 0.312, p <.001) and government support (β = 0.317, p<.001). However, the peer pressure factor was not significantly related to adoption intent (β = .080, p = .231). The results are demonstrated in Table 57.

Table 57: Hypotheses Testing for the External Factors Dimension Variables

Relationship	Standardised Regression	S.E.	t-value	P	Hypothesis Confirmed?
H3a: Existing Regulations -> Adoption Intent	.312	.066	4.077	<.001	Yes
H3b: Government Support -> Adoption Intent	.317	.099	3.586	<.001	Yes
H3c: Peer Pressure -> Adoption Intent	.080	.070	1.198	.231	No
R^2 = .367, p < .001					

7.4.4 Quality Factors

Amos results for the quality factors are presented in Figure 30.

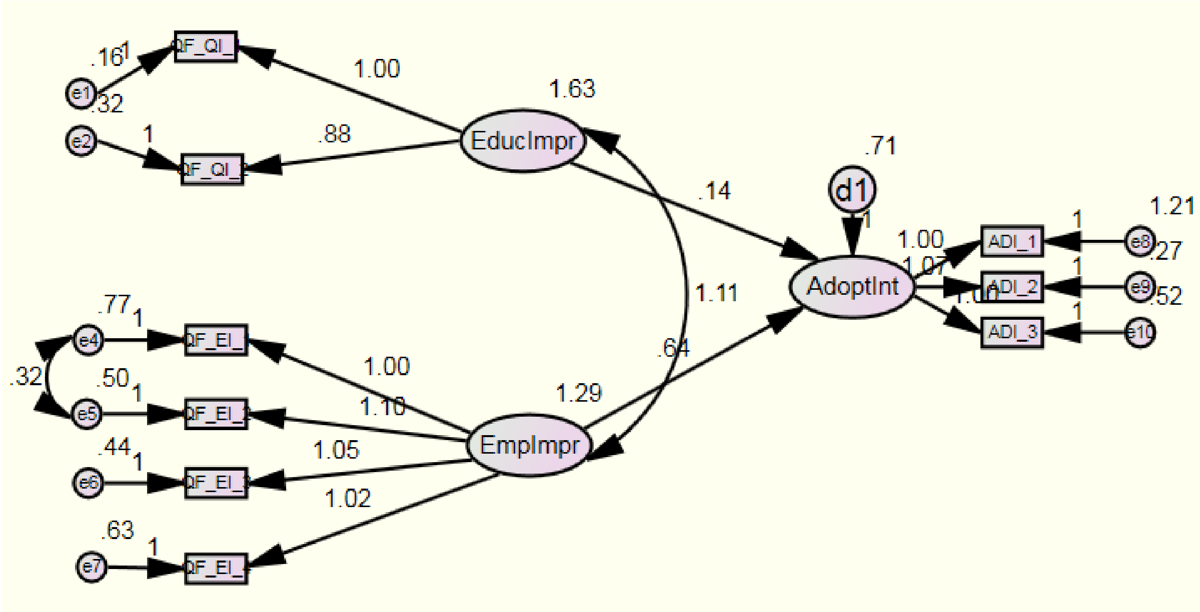


Figure 30: Amos Results for Quality Factors

Of the two quality factors, expected employment improvement demonstrated a positive, statistically significant relationship to adoption intent (β=.602, p < .001). At the same time, no significant relationship was observed for the education improvement variable (β=.145, p = .091). The results are presented in Table 58.

Table 58: Hypotheses Testing for Quality Factors Dimension Variables

Relationship	Standardised Regression	S.E.	t-value	P	Hypothesis Confirmed?
H4a: Education Improvement -> Adoption Intent	.145	.082	1.690	.091	No
H4b: Employment Improvement -> Adoption Intent	.602	.102	6.288	<.001	Yes
R^2 = .436, p < .001					

7.4.5 Barriers to Adoption

Amos results for barriers to adoption are presented in Figure 31.

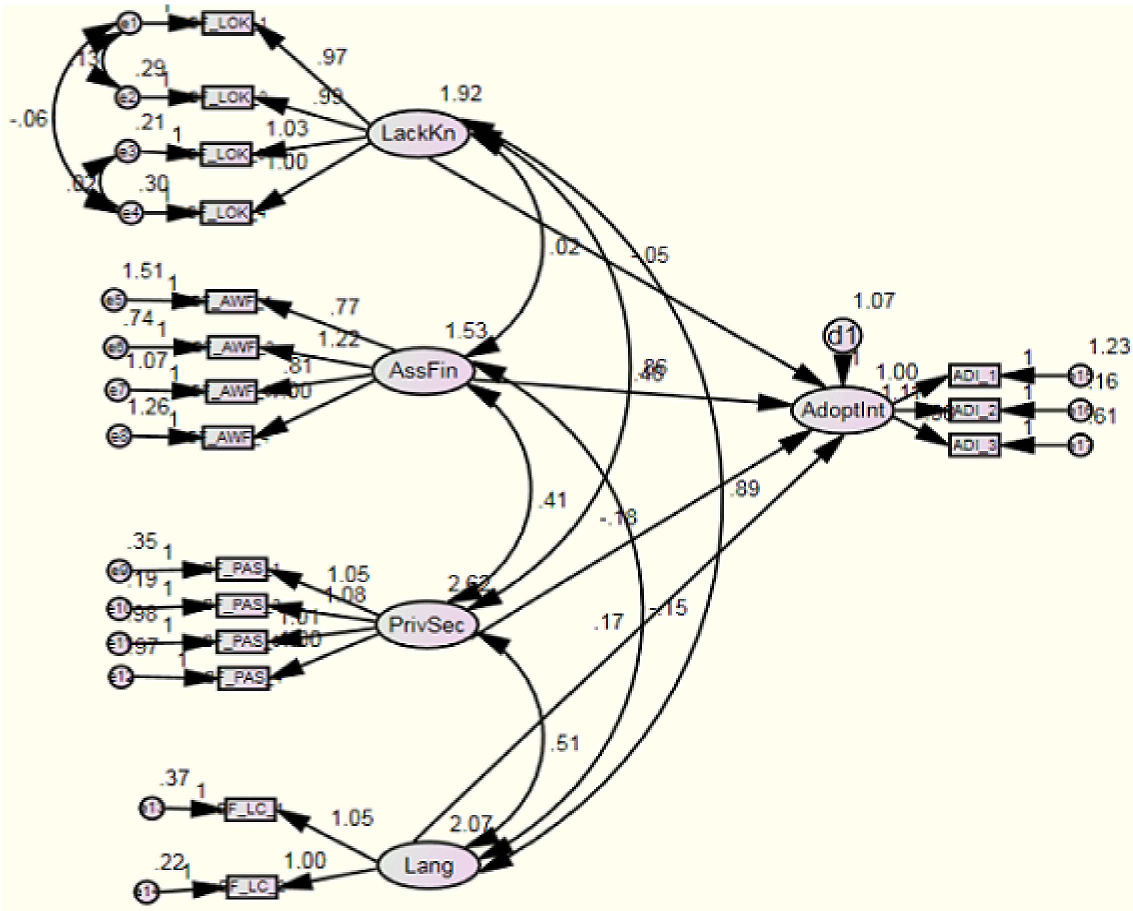


Figure 31: Amos Results for Barriers to Adoption

Of the barriers to adoption, three appeared to have a statistically significant influence on adoption intent. As expected, all relationships were negative. Association with only finance was the strongest factor (β = -0.494, p < .001), followed by privacy and security concerns (β = -0.247, p < .001) and language concerns (β = -0.199, p = .002). The only factor that did not show a statistically significant influence was lack of knowledge (β = -0.062, p = .354). The results are presented in Table 59.

Table 59: Hypothesis Testing for Barriers to Adoption Dimension Variables

Relationship	Standardised Regression	S.E.	t-value	P	Hypothesis Confirmed?
H5a: Lack of Knowledge -> Adoption Intent	-.062	.058	-.928	.354	No
H5b: Association with Finance -> Adoption Intent	-.494	.071	6.785	<.001	Yes
H5c: Privacy and Security Concerns -> Adoption Intent	-.247	.048	-3.822	<.001	Yes
H5d: Language Concerns -> Adoption Intent	-.199	.055	3.036	.002	Yes
R^2 = .230, p < .001					

7.5 Chapter Summary

This chapter presented the results of the quantitative analysis of the collected survey data. The total number of valid responses was deemed adequate for further analysis, and the data displayed high levels of internal consistency and validity. Of the 16 hypotheses formulated within the conceptual framework, 11 were confirmed by the results of the SEM: 3 out of 5 for the technology dimension, 2 out of 2 for the organisational dimension, 2 out of 3 for the environment dimension, 1 out of 2 for the quality dimension, and 3 out of 4 for the barriers to adoption dimension. The next chapter offers a comprehensive review and discussion of the study findings.

8 Discussion

8.1 Introduction

This chapter offers a comprehensive discussion of the study results. The results of the qualitative and quantitative analyses are linked to the study goals and objectives: 1) identifying positive and negative factors influencing blockchain adoption in Saudi HEIs; 2) developing and crystallising a framework of blockchain adoption; and 3) testing the effect of factors/dimensions on blockchain adoption. Section 8.2 discusses the findings with regard to the main research question posed in this study. Section 8.3 begins by revisiting the research questions and main propositions to discuss their evolution as the research progressed. This follows from the changes applied after the model presentation and analysis in Chapter 6. Section 8.4 offers a comparative overview of the results in Phase I and Phase II. Sections 8.5-8.9 discuss the findings in relation to the research subquestions and hypotheses. The key relationships are identified and discussed in the context of Saudi Arabia as well as the general propositions in the existing literature related to blockchain adoption in education.

8.2 Main Research Question

The main research question in the study was:

How can we develop a holistic blockchain adoption model for Saudi HEIs?

The approach to developing a holistic actionable model successfully followed the design science approach (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). The model was developed and evaluated in six steps:

1. **Problem identification and solution value**. A thorough literature review enabled the existing knowledge gaps to be identified such as the absence of a holistic framework for blockchain adoption designed specifically for Saudi HEIs. Before this study’s inception, there were no empirically validated blockchain adoption frameworks of such kind. Accordingly, the research question was formulated and split into subquestions to deal with the complexity more effectively.

2. **Define the solution objectives** Next, the objectives were formulated to provide an actionable framework of blockchain adoption for Saudi HEI administrators. Resources to meet the objectives were discussed: available theoretical and

empirical studies of adoption, industry experts' opinions, and a large-scale survey to confirm the role of specific model elements.

3. **Design and development.** The actual development of the model involved several steps. First, the theoretical literature on blockchain adoption was consulted to select the most appropriate theoretical foundations and determine the main dimensions of the framework: technology, organisation, environment, quality and barriers. Second, the selected theories were integrated to offer a holistic adoption perspective. Third, the empirical literature was reviewed to identify the factors within each dimension that showed a strong influence on blockchain adoption in higher education.

4. **Demonstration.** The model was presented to a group of industry experts for evaluation and analysis. In the course of the interviews, the experts defined the most viable application of the proposed framework which is for blockchain-supported school certificates. Accordingly, the initial model was refined by integrating additional factors and removing some factors that the experts considered less important in the context of Saudi HEIs.

5. **Evaluation.** The refined model was empirically tested and validated by conducting a survey on a large group of higher education professionals in Saudi Arabia. The evaluation confirmed the proposed model's efficacy in explaining the blockchain adoption process in Saudi HEIs.

6. **Communication.** The results of the model development and testing are presented and thoroughly discussed in this thesis. A series of publications are expected for further dissemination of the acquired knowledge. The process has been already initiated by the submission of the literature review part of the thesis to a peer reviewed journal and the qualitative analysis of the framework to a conference.

8.3 Evolution of Research Subquestions and Objectives

As discussed in Chapter 2 of the current thesis, blockchain adoption in education is lagging behind other industries such as finance, supply chain management and healthcare. Nevertheless, the progress in research has been notable over the past few years, and it allows strong parallels to be drawn to other industries in terms of adoption factors.

Following this logic, the original framework developed for this study was based on the technology adoption theories applied at the organisational level (Rogers E. , 2003; Tornatzky & Fleischer, 1990) and available empirical literature covering the adoption of blockchain in education (El Nokiti & Yusof, 2019; Fedorova & Skobleva, 2020; Kosmarski, 2020; Ullah, Al-Rahmi, Alzahrani, Alfarraj, & Alblehai, 2020; Widjaja, Cassandra, Widjaja, Prabowo, & Fernando, 2020). At the same time, recognising contextual differences in the blockchain adoption process, the study refined the original framework based on the interviews with the Saudi IT and education professionals. Based on the interviews' analyses, five dimensions comprising 16 factors in total were retained as significant. The resulting framework, to the best knowledge of the author, became the first of its kind to explain and predict blockchain adoption by Saudi HEIs. The following research questions and hypotheses were formulated and investigated:

RQ1: Which technology factors influence blockchain adoption in Saudi HEIs?

H1a: blockchain's relative advantage positively influences its adoption intent in Saudi HEIs.

H1b: blockchain's complexity negatively influences its adoption intent in Saudi HEIs.

H1c: blockchain's trialability positively influences its adoption intent in Saudi HEIs.

H1d: blockchain's observability positively influences its adoption intent in Saudi HEIs.

H1e: blockchain's compatibility positively influences its adoption intent in Saudi HEIs.

RQ2: Which organisational factors influence blockchain adoption in Saudi HEIs?

H2a: top management support positively influences blockchain adoption intent in Saudi HEIs.

H2b: organisational readiness positively influences blockchain adoption intent in Saudi HEIs.

RQ3: Which external factors influence blockchain adoption in Saudi HEIs?

H3a: existing regulations negatively influence blockchain adoption intent in Saudi HEIs.

H3b: government support positively influences blockchain adoption intent in Saudi HEIs.

H3c: peer pressure positively influences blockchain adoption intent in Saudi HEIs.

RQ4: Which quality factors influence blockchain adoption in Saudi HEIs?

H4a: Education improvement positively influences blockchain adoption intent in Saudi HEIs.

H4b: Employment improvement positively influences blockchain adoption intent in Saudi HEIs.

RQ5: What are the barriers to blockchain adoption in Saudi HEI?

H5a: lack of knowledge negatively influences blockchain adoption intent in Saudi HEIs.

H5b: Association with finance negatively influences blockchain adoption intent in Saudi HEIs.

H5c: Privacy and security concerns negatively influence blockchain adoption intent in Saudi HEIs.

H5d: Language concerns negatively influence blockchain adoption intent in Saudi HEIs.

Following is a discussion of the study results based on the research questions.

8.4 Comparison of the Qualitative and Quantitative Results

A model with a good predictive power should generally demonstrate similar to the predicted results when tested on large populations. One of the main goals of this study was to produce a working, reliable model of blockchain adoption in Saudi HEIs taking into account the specifics of the context. Phase I of the research revised the initial model and presented a finalised framework with 16 independent factors deemed significant for blockchain adoption which were later empirically tested in Phase II on a large sample of IT professionals and administrators in Saudi HEIs. Table 60 provides a comparison of the predicted results developed during Phase I and the actual results obtained during Phase II of the research. It can be seen that 11 out of 16 hypothesised relationships were confirmed. On the one hand, this suggests that the developed model was relatively robust in explaining blockchain adoption in Saudi HEIs. On the other hand, 5 invalidated predictions require further analysis. The next sections discuss the influence of each factor on blockchain adoption individually and within their corresponding dimensions.

Table 60: Comparison of Qualitative and Quantitative Results

Research Questions and Hypotheses	Interviews*	Survey	Findings
RQ1: Which technology factors influence blockchain adoption in Saudi HEIs?			
H1a: Relative Advantage -> Adoption Intent	Strong positive	Supported	Positive
H1b: Complexity -> Adoption Intent	Moderate negative	Supported	Negative
H1c: Trialability -> Adoption Intent	Moderate positive	Not supported	-
H1d: Observability -> Adoption Intent	Moderate positive	Supported	Positive
H1e: Compatibility -> Adoption Intent	Moderate positive	Not supported	-
RQ2: Which organisational factors influence blockchain adoption in Saudi HEIs?			
H2a: Top Management Support -> Adoption Intent	Strong positive	Supported	Positive
H2b: Institutional Readiness -> Adoption Intent	Strong positive	Supported	Positive
H2c: Organisational Size -> Adoption Intent	Path removed	-	-
RQ3: What environmental factors influence blockchain adoption in Saudi HEIs?			
H3a: Existing Regulations -> Adoption Intent	Strong negative	Supported	Positive
H3b: Government Support -> Adoption Intent	Moderate positive	Supported	Positive
H3c: Peer Pressure -> Adoption Intent	Moderate positive	Not supported	-
RQ4: Which quality factors influence blockchain adoption in Saudi HEIs?			
H4a: Education Improvement -> Adoption Intent	Strong positive	Not supported	-
H4b: Employment Improvement -> Adoption Intent	Strong positive	Supported	Positive
Administration Improvement	Path removed	-	-
RQ5: What are the barriers to blockchain adoption in Saudi HEIs?			
H5a: Lack of Knowledge -> Adoption Intent	Moderate negative	Not supported	-
H5b: Association with Finance -> Adoption Intent	Strong negative	Supported	Negative
H5c: Privacy and Security Concerns -> Adoption Intent	Moderate negative	Supported	Negative
H5d: Language Concerns -> Adoption Intent	Moderate negative	Supported	Negative
Risk Avoidance -> Adoption Intent	Path removed	-	-
Lack of Specialists -> Adoption Intent	Path removed	-	-
Lack of Infrastructure -> Adoption Intent	Path removed	-	-
Lack of General Readiness -> Adoption Intent	Path removed	-	-
Lack of Visibility -> Adoption Intent	Path removed	-	-

8.5 The Role of Technology Factors

The role of technology factors in the blockchain adoption process is well recognised in both the theoretical and empirical literature. Within the TOE framework, technology innovation represents an array of novel technology solutions that could be beneficial for a company (Lustenberger et al., 2021; Tornatzky et al., 1990). The DOI, in turn, proposes that innovations contain five important characteristics that that make them attractive for organisations: relative advantage, observability, complexity, trialability and compatibility (Rogers, 2003). Recent reviews of blockchain adoption in various industries have demonstrated that these factors are also important for the adoption of blockchain at the organisational level (e.g., Clohessy & Acton, 2019; Clohessy et al., 2020; Hartley et al., 2022). The results of the qualitative research conducted in the context of the current study largely agreed with the general propositions about technological factors reported in the literature. There was universal consensus among the expert interviewees that all technological factors proposed by the DOI theory were relevant for blockchain adoption in Saudi HEIs. The study, therefore, investigated the influence of all five DOI factors.

8.5.1 The Influence of Relative Advantage

Within the DOI, relative advantage of a new technology is regarded as the strongest predictor of its adoption (Lustenberger et al., 2021; Rogers, 2003). This was largely confirmed by the results of the qualitative data analysis in this study. Relative advantage was by far the most consistently and highly rated technology adoption factor by the interviewees. This is logical because for organisations, the key consideration in adopting a technology rests on whether it should replace the existing systems and whether it would be a good decision from an investment perspective in the long run. In the case of blockchain, however, the situation is more complex because it has been consistently compared to a wide range of existing technologies, such as spreadsheets, ERP systems, CRM, internal databases and security mechanisms (e.g., Hartley et al., 2022; Kouhizadeh et al., 2021; van Hoek, 2019; Xu et al., 2021). This was also reflected in the interviews, as the respondents spoke about blockchain's advantage in relation to security programs, trust-enabling technologies, administration programs, and digital education applications. Therefore, blockchain was not juxtaposed against a single legacy technology system it was expected to replace, but rather considered a groundbreaking technology that can challenge a host of existing systems and applications. In fact, this is confirmed by a wide range of blockchain existing and potential applications in education as reported in the literature: from certificates to education platforms to academic integrity and administration (Capece et al., 2020; Fedorova & Skobleva, 2020; Jirgensons & Kapieniks, 2018; Kamisalic et al., 2020).

Despite the predicted strong influence on adoption in the literature and during the interviews, the SEM analysis demonstrated only a moderate strength ($\beta = .237, p = .043$). Therefore, while the hypothesis was confirmed, the influence of relative advantage as a factor was not as strong as predicted. This result could be explained by the specifics of blockchain applications in industry. The DOI proposes that the perceived benefits of a technology innovation and its relative advantage depend strongly on the innovation nature and the adopting population (Rogers, 2003). As such, different industries will recognise blockchain's relative advantage differently, based on their specific needs and expectations (Carson et al., 2018). As noted earlier, blockchain applications in education fall behind other industries such as finance, healthcare or supply chain management to name a few (e.g., Alazab et al., 2021; Hasselgren et al., 2020; Kulkarni & Patil, 2020). Whereas in those industries, there is a strong understanding about the specific business processes that can benefit from blockchain adoption, education institutions may still be in the process of discovering its advantages in various application areas. Indeed, blockchain in education so far seems to be strongly established only for diplomas with practical applications in other educational aspects being in the development stages. As such, a weaker than expected impact of blockchain's relative advantage in the context of Saudi HEIs is explained.

8.5.2 The Influence of Compatibility

Compatibility is considered another positive factor in technology adoption within DOI (Rogers, 2003). While compatibility is a technology feature, the theoretical treatment of this aspect goes beyond connecting well to legacy systems. It is seen in a broader sense, touching upon regulatory and technical demands as well as organisational goals and objectives (Hartley et al., 2021; Lustenberger et al., 2021). It is not surprising then that in this study, the respondents spoke of the importance of blockchain compatibility with all aspects of HEI management: from services to administration. The survey results, however, did not confirm the link between compatibility and blockchain adoption in Saudi HEIs ($\beta = -.009, p = .863$), which requires further discussion.

It should be noted that some interviewees, in fact, did not consider compatibility as influential in the blockchain adoption process. The key arguments seem to converge on the idea that blockchain is inherently compatible with the existing systems used in Saudi HEIs, and, as a result, seeking compatibility should not be a concern. This could be explained by the well-developed and integrated cloud solutions in Saudi HEIs. Blockchain researchers generally consider the cloud infrastructure as conducive to blockchain adoption (e.g., Clohessy and Acton, 2019; Hartley et al., 2021; Orji et al., 2020). Therefore, compatibility with the existing IT systems at the institutional level may not be seen as a critical issue for Saudi HEIs. Further, existing research on blockchain adoption suggests that for organisational users, a much larger concern rests with non-technological compatibility. Specifically, the issue of compatibility with the existing privacy laws or data management standards typically overrides technology compatibility concerns (Clohessy et al., 2020; Rauchs et al., 2019). Consequently, such concerns were proven to be substantial barriers to blockchain adoption in Saudi HEIs as discussed later on.

8.5.3 The Influence of Observability

The DOI proposes that the technologies whose positive effects can be observed more easily will be adopted more readily (Rogers, 2003). This effect, however, could be less pronounced with novel, less mature technologies like blockchain. This was emphasised in a number of works on blockchain adoption and applications which noted the technology's relative infancy (Clohessy et al., 2020; Dobrovnik et al., 2018; Hartley et al., 2021). Some authors also argued that the lack of observability leads to many blockchain projects being shelved before they could show positive results (Rauchs et al., 2019). Uncertainty regarding the observability effect on blockchain adoption was also clearly traced during the interviews in this study. There were opinions both in support of blockchain observability and against it which made it difficult to formulate the specific degree or direction of that effect. It was assumed then that for the decision makers in Saudi HEIs, the positive effects of blockchain should be tangible enough and related to both internal operations and external effects to become influential.

Still, the results of the survey analysis showed that the effect of observability on blockchain adoption intent was statistically significant and relatively strong ($\beta = .411$, $p < .001$). Therefore, it was demonstrated that blockchain's observability positively influences the decision to adopt it. This result can be explained by the knowledge effect of the research sample. As noted in Chapter 6, of the 10 interviewees, only 5 expressed a deep understanding of the topic, whereas the other 5 acknowledged somewhat limited knowledge. Consequently, there was no consistency among the interviewees regarding blockchain adoption in education, including Saudi Arabia. Those with deeper knowledge of the subject, in fact, spoke about the observability of the technology more positively. In a similar manner, survey respondents who were more knowledgeable and technically adept in blockchain technology could have recognised its potential for education institutions better.

8.5.4 The Influence of Complexity

Technology complexity is considered a negative factor within DOI because the more degree of effort that is required to understand and use technology, the harder it is to adopt it (Rogers E. , 2003; Saberi, Kouhizadeh, & Sarkis, 2019). Over the course of the interviews, it became apparent that complexity is, indeed, a negative feature of blockchain which could slow its adoption in Saudi HEIs. The respondents acknowledged such issues as a lack of blockchain understanding and technical expertise, which would inevitably require additional training and/or hiring blockchain specialists or consultants. This is largely in line with the existing literature that lists these issues due to blockchain's novelty (Clohessy & Acton, 2019; Falcone, Steelman, & Aloysius, 2021; Sternberg, Hofmann, & Roeck, 2021).

The results of the survey analysis confirmed the negative effect of complexity on blockchain adoption intent in Saudi HEIs ($\beta = -.186$, $p = .027$), although the overall negative effect was somewhat lower than expected. Perhaps, some explanation for this can be attributed to good technology financing and well-developed IT departments in Saudi HEIs. During the interviews, the respondents recognised the perceived complexity of blockchain; however, they also argued that the stronger a HEI's IT department is believed to be, the lower the impact of complexity is expected to be. Indeed, existing research demonstrated that strong IT departments and infrastructure help organisations overcome blockchain complexity issues (Clohessy & Acton, 2019; Sternberg et al., 2021). Therefore, the results of this study confirm the general propositions regarding blockchain complexity but at the same time show how perceived complexity may be countered.

8.5.5 The Influence of Trialability

In DOI, trialability is considered an important factor of adoption because it allows organisations to test a technology at a low cost before deploying it (Rogers, 2003; Rosenberg, 1982). In relation to blockchain, previous studies found that organisations would postpone its implementation until the concept is well proven in practice for the applications they sought (Lustenberger et al., 2021; Schmitt et al., 2019). Similar arguments were provided by some interviewees who described standard procedures for implementing new technologies in their HEIs with trials coming prior to organisation-wide deployment. However, the results of survey data analyses did not confirm the relationship hypothesis ($\beta = .226$, $p = .094$). The effect of trialability, therefore, was not present for blockchain adoption in Saudi HEIs, which requires further discussion.

The lack of a trialability effect could be the result of routine innovation trials in Saudi HEIs. As several interviewees acknowledged, their institutions periodically test technology innovations which have the potential to benefit their organisations. Blockchain then, would be considered another technology for such regular testing. In fact, trialability is sometimes discarded from DOI-based adoption studies because trials are usually imposed by organisations that consider potential technologies as beneficial (Agi & Jha, 2022; Chong, Lin, Ooi, & Raman, 2009). In other words, whether an innovation is easier or more difficult to test becomes irrelevant when an organisation is keen on exploring it. This could be the case with blockchain in Saudi HEIs. The history of cloud computing adoption also suggests that when a technology is seen as having high degree of potential, Saudi HEIs do not consider trialability to be a serious factor.

8.6 The Role of Organisational Factors

The organisational dimension within the TOE framework incudes organisational resources, structures and communication processes that influence decision making regarding technology adoption (Baker, 2012; Tornatzky & Fleischer, 1990). The original framework is rather flexible regarding what specific factors should be included in the model. For example, a recent review of blockchain adoption studies by Clohessy et al. (2020) identified 13 such factors. However, their strength of influence varied, and only three were described as important: organisational readiness, top management support and organisational size. These three factors were thoroughly investigated in this study in the qualitative analysis stage which largely replicated the findings by Clohessy et al. (2020), including a weaker effect of organisational size. The discussion of the findings for each factor is provided below.

8.6.1 The Influence of Organisational Readiness

Organisational readiness is a comprehensive construct in TOE which covers a variety of resources. Earlier research assessed organisational readiness from the perspective of technological and financial resources (Iacovou, Benbasat, & Dexter, 1995). Recently, organisational readiness, especially when it comes to blockchain, was expanded substantially (e.g., Clohessy & Acton, 2019; Clohessy et al., 2020). The analysis of qualitative data in this research largely confirmed the current literature on blockchain adoption by considering organisational readiness as a combination of technological, human and financial resources. Indeed, organisations that lack specialists, the appropriate level of technology development and technology investments are often considered incapable of adopting blockchain successfully (Post et al., 2018; Rauchs et al., 2019).

The results of the survey analysis further supported the claim that organisational readiness is a strong predictor of blockchain adoption ($\beta = .411$, $p < .001$). Therefore, the results of this research aligned with the results of similar studies on blockchain conducted recently. On a side note, some interviewees even dismissed the lack of one aspect of organisational readiness by arguing that their institutions would be ready to acquire the lacking resources if necessary. This may offer additional research avenues in the future.

8.6.2 The Influence of Top Management Support

Top management support, along with organisational readiness, has been empirically confirmed as a key factor in the adoption of innovation in general and blockchain specifically (Clohessy, et al., 2020; Dong, et al., 2009; Duan, et al., 2020; Wong, et al., 2020). The results of this study confirmed these findings. In the course of qualitative data analysis, top management support was seen not only as an influential organisational factor but also as "essential," "necessary," "significant" and "most important." Further, this factor was seen as the most important among the organisational dimension variables in influencing blockchain adoption by Saudi HEIs.

In general, top management support in the adoption studies is considered from the perspective of overcoming adoption barriers, creating a technology vision, and enabling sufficient resource allocation for new innovations (Lustenberger et al., 2021). However, it appears that in the case of Saudi HEIs, top managers are primarily considered the key decision makers in adoption decisions per se. Due to stronger hierarchical structures in

Saudi organisations, top management support plays a stronger role. This, however, was not confirmed by the survey results, since the effect of the top management support factor was similar to that of organisational readiness ($\beta = 0.374$, $p < .001$). It is reasonable to assume then that top management support and organisational readiness are equally important when it comes to blockchain adoption in Saudi HEIs.

8.6.3 The Influence of Organisational Size

Organisational size is the often-considered construct in the organisational dimension of the TOE framework. Recently, Clohessy et al. (2020) identified it as the third most researched organisational variable in blockchain adoption research. However, the results of the empirical research so far have been less conclusive than for organisational readiness and top management support in the context of blockchain adoption. Some studies found that larger organisations were better suited to blockchain adoption due to resource availability, others found that smaller companies were more agile and elastic in relation to embracing new innovations (Mendling et al., 2018; Tapscott & Tapscott, 2016; Wang et al., 2016). This uncertainty was traceable during the interviews in this study as the respondents were split regarding which HEI size would be better suited for blockchain adoption.

The decision to not consider organisational size as an organisational factor was also made due to seeming agreement among the respondents that size was not a deterministic term but rather a convenience measure of organisational resourcefulness. This follows the logic of innovation adoption studies criticising organisational size as being less specific and, therefore, meaningful than more concrete measures of resources required for successful adoption (Baker, 2012). Resourcefulness, on the other hand, is reflected in the organisational readiness variables which considered three major types of resources for blockchain innovation. For these reasons, the decision to not consider the organisation size – adoption intent path is justified. Still, the effect of organisational size was measured as one of the control variables, and the relationship was not confirmed. HEI size then was not proven as a significant factor in the blockchain adoption process by Saudi HEIs.

8.7 The Role of Environmental Factors

The environmental context in the TOE framework includes factors beyond the firm's direct control that can influence innovation adoption (Baker, 2012; Tornatzky & Fleischer, 1990). Market characteristics, industry characteristics, existing legal frameworks and other factors have been considered for blockchain adoption (Clohessy & Acton, 2019; Lustenberger et al., 2021; Zheng et al., 2018). However, environmental factors are often regarded as contingent upon context and, therefore, specific to different industries and countries. After the completion of the qualitative data analysis, this study considered three environmental factors: existing regulations, government support and peer pressure. The effect of existing regulations and government support on blockchain adoption by Saudi HEIs was confirmed while the effect of peer pressure was not. The results for each factor are discussed below.

8.7.1 The Influence of Existing Regulations

Government regulations represent an important area of influence on emerging technologies, especially if such technologies are groundbreaking, redefining entire industries (Piscini, Cotteleer, & Holdowsky, 2018). For organisations that consider adopting such technologies, there is a large degree of uncertainty with regard to how their use would be legally defined and regulated in the future. With regard to blockchain, the current regulations do not always readily recognise how to govern it from a legal perspective. Salmon and Myers (2019), for example, pointed out that legal authorities would need to create better frameworks to regulate blockchain effectively. The same concerns were also expressed by the interviewees in this study who recognised that the existing regulations may not be able to duly cover various aspects of blockchain adoption and applications in Saudi HEIs.

The significant influence of the existing regulations on blockchain adoption was confirmed by the results of the survey data ($\beta = 0.312$, $p <.001$). Surprisingly, however, the direction of the relationship was possible, thereby suggesting that the existing regulations in fact supported blockchain adoption intent in Saudi HEIs. Several explanations for this contradictory result are possible. First, when speaking of regulations, the negative effect of existing regulations on blockchain adoption is often attributed to uncertainty (e.g., Farooque et al., 2020; Lustenberger et al., 2021; Salmon & Myers, 2019). Perhaps, when it comes to Saudi Arabia, the existing legislation is seen as sufficiently mature, leaving less ambiguity about blockchain. Such optimism may also be connected to a vibrant and conducive legal framework created for cloud technologies in the country. Further, the respondents may have attributed such optimism to the Vision 2030 policies which are very lenient for technology innovations of various kinds. It would be, therefore, useful to examine the specific aspects of existing regulations in Saudi Arabia and identify which ones provide such confidence for potential organisational adopters of blockchain.

8.7.2 The Influence of Government Support

Governments are stakeholders in technology innovation processes, along with rival firms, organisational customers and partners. The TOE recognises the role of government as either positive or negative depending on whether certain technologies are seen as prospective or threatening (Baker, 2012). With regards to blockchain, government support is usually recognised as a positive driver of adoption because of the technology's newness (Chen et al., 2018; Farooque et al., 2020; Tapscott & Tapscott, 2016). The results of the qualitative analysis confirmed these literature findings. Further, it was noted that such support increased during the COVID-19 pandemic due to an increased focus on online technologies in education. This is also in line with the existing literature which reported accelerated blockchain adoption in various sectors around the globe (Shah, Shah, Tanwar, & Kumar, 2021; Yang, Zhang, & Shi, 2021). The results of the survey analysis further confirmed the positive role of government support in blockchain adoption by Saudi HEIs ($\beta = 0.317$, $p<.001$). Therefore, the study results agreed with the existing theoretical and empirical postulates regarding the positive role of government support on blockchain adoption by organisations.

8.7.3 The Influence of Peer Pressure

Competitors, along with the government, are traditionally regarded as the most influential external stakeholders in the technology adoption literature (Iacovou, Benbasat, & Dexter, 1995; Penttinen & Tuunainen, 2009). The extent of peer (also known as mimetic) pressure regarding technology adoption arises from the perceived success of rival organisations linked to new technology use. Accordingly, as the DOI theory proposes, the innovators exert competitive pressures on other companies in their industry to promote further technology diffusion (Rogers, 2003). Yet, the effect of peer pressure on blockchain technology adoption is not clearly established empirically (Iansiti & Lakhani, 2017;

Kouhizadeh et al., 2021; Pilkington, 2016). The analysis of qualitative data in this study also provided mixed conclusions about the effect of peer pressure on blockchain adoption by Saudi HEIs. Whereas the supporters of the effect, in line with the theory, pointed towards competitiveness blockchain provides, the opponents believed that technology development in HEIs goes in accordance with internal technology development plans. In the end, the survey results did not demonstrate the significant effect of peer pressure ($\beta = .080$, $p = .231$).

The absence of a relationship between peer pressure and blockchain adoption In this study can be explained in several ways. First, it is emphasised in both the theoretical and empirical literature that peer pressure works best with technologies that are already established (Baker, 2012; Hartley et al., 2021). Since blockchain remains in the early application lifecycle, and not many HEIs in Saudi Arabia are using it, there is little mimetic pressure on other HEIs to adopt it. Granted, in some cases, even technologies in the early stages are pushed to adoption through partnerships or collaborative networks that promote specific technology use (Lustenberger et al., 2021). However, this is not the case with Saudi HEIs either because blockchain is still not widespread, and Saudi HEIs can exercise independent policies in relation to technology choices. Finally, peer pressure can be seen as only one of the factors in a large composition of market dynamics (Clohessy et al., 2020). These dynamics may, in fact, challenge the existing technology status quo and pressure organisations to adopt blockchain. However, this could be a composition effect rather than a single factor effect of peer pressure. Therefore, at least at this point in time, peer pressure alone is not sufficient to substantially influence blockchain adoption among Saudi HEIs.

8.8 The Role of Education Quality Factors

While blockchain is a relatively new technology in the context of the education sector, its potential contribution is rather high. Generally, it is recognised that innovative technologies can improve education quality outcomes, especially in developing countries (Duan et al. 2017, Xu et al. 2017, Farah et al. 2018, Williams, 2019). Existing use cases identify at least a dozen working applications and many more potential applications after integrating blockchain design platforms with the existing systems. As determined in Chapter 2 of this thesis, enhancing education quality could occur in three ways: 1) through an increased operational efficiency and, therefore, reduced cost of education; 2) through new approaches to course delivery and enhanced learning environments; and 3) through easily verifiable lifelong education credentials (AlHarthy et al., 2019; Alammary et al., 2019; Bhaskar et al., 2020; Kosmarski, 2020). Accordingly, this thesis identified education quality improvements in terms of improving employment prospects for graduates, improving the quality of education services and improving the quality of school administration.

8.8.1 The Influence of Intent to Reduce Unemployment

Reducing graduate unemployment is a context-specific issue for Saudi Arabia's education as the rate continues to hover around 28%, with over half of the unemployed holding at least a bachelor's degree (O'Neill, 2022). Improving access to the labour market and empowering students are considered key indicators of education quality (Al-Ramahi & Odeh, 2020; Harvey, 2006). Blockchain is considered to be a technology that achieves this in two ways: 1) by offering an accelerated, easily verifiable system of learning credentials and certificates; and 2) by creating job opportunities across the blockchain system itself, which is related to engineering, software development, education, administration and other related fields (Bucea-Manea-Tonis et al., 2021; Guustaf et al., 2021; Hameed et al., 2019).

The results of this study confirmed the aforementioned assertions through both qualitative and quantitative analyses. The majority of the interviewees agreed on the strong effect of blockchain's potential to reduce unemployment which, in turn, may prompt its faster adoption. The inherent features of blockchain, such as immutability and transparency, were commonly discussed as important factors in this regard. Accordingly, the interviewees pointed to the ease and speed of the job application process and the verification of student credentials using blockchain certificates. The results of the survey data analysis further confirmed the link between unemployment reduction and blockchain adoption intent in Saudi HEIs (β=.602, $p < .001$). Therefore, the study results confirmed the existing propositions in the literature. On the other hand, there was some degree of concern among the respondents about the ability of blockchain to provide employment benefits to all students and not to early adopters only. This kind of investigation was beyond the scope of this thesis but could, nevertheless, offer an interesting avenue for further research.

8.8.2 The Influence of Perceived Quality of Service Improvements

Service quality in general refers to how well an organisation manages to deliver its products and/or services to the customers (Prakash, 2019). Since HEIs are considered a part of the service-providing industry, the issue of service quality is especially important to them (Galeeva, 2016; Latif, Latif, Sahibzada, & Ullah, 2019). Technology is often seen as a way to improve service quality in HEIs (Sugandi & Kurniawan, 2020). As discussed in Chapter 2 of this thesis, blockchain improvements to higher education service quality are expected to arise from organisation-centred improvements such as efficiencies, administration and provision of courses and valuations. It is logical then that the interview respondents saw improvements to quality of services arising from blockchain as a combined effect on administrative and course delivery services. As such, the qualitative analysis confirmed the proposition of service quality improvements with blockchain but through a broader lens which included administration and learning service provisions.

However, the results of the survey analysis did not support the link between improvements to education service quality and blockchain adoption intent (β=.145, p = .091). This may be explained by the fact that most of the advantages that blockchain is expected to bring to education service quality remain in the conceptual stage at the moment. Indeed, as the research shows, process automation, operational efficiencies, data security and course delivery have been proposed in the form of models, but their realisation in practice is still lacking (Alam & Benaida, 2020; Awaji et al., 2020; Bhaskar et al., 2020; Mikroyannidis et al., 2018). Therefore, it may still be unclear what particular aspects of service quality blockchain brings to Saudi HEIs. This could also be indirectly assumed from the interviews, as the majority of the respondents did not offer specific examples of service quality improvements that blockchain delivers or might deliver to their institutions.

8.9 The Role of Barriers to Adoption

The presence of factors that obstruct or slow the adoption of innovative technologies is well recognised in both DOI and TOE theories (Baker, 2012; Rogers, 2003; Tornatzky et al., 1990). Being a relatively recent technology, blockchain is at the stage of implementation where many barriers are likely to exist at the organisational level. The empirical literature on blockchain adoption in education identified over a dozen barriers attributed to the key dimensions of the TOE framework: technological, organisational and environmental (e.g., Bhaskar et al., 2020; Ma and Fang, 2020; Yue et al., 2020). However, a closer analysis of the barriers has led to an important observation that many of them simply reflected the lack of enabling factors of adoption (for example, a lack of resources and infrastructure) or reiterated the negative dimensional factors (for example, technology complexity and regulations). Such factors were excluded from the analysis of barriers to blockchain adoption by Saudi HEIs. Also, in the course of the interviews, certain barriers were either mentioned rarely or not considered worthy of investigation. In the end, four barrier factors were retained for the survey: the lack of knowledge about blockchain, association with finance only, concerns regarding privacy and security and language concerns. The effect of each of these factors on blockchain adoption is discussed next.

8.9.1 Lack of Knowledge

The DOI posits that innovations must be understood before being adopted (Rogers, 2003). Innovations that are new and perceived complex will take more time to gain followers. Existing research indicates that there is a general deficiency in blockchain knowledge among the organisational decision makers, which makes it more difficult to accept and adopt (Falcone et al., 2021; Post et al., 2018; Rauchs et al., 2019). Consequently, a general lack of blockchain awareness in the educational sector was reported by Fedorova and Skobleva (2020). The lack of knowledge about blockchain also led to the perceptions of it being too complex (Castro and Au-Young-Oliveira, 2021; Liu & Zhu, 2021). In the course of the interviews in this study, similar issues were identified. The respondents claimed that little was known about blockchain and its applications to confidently start adopting it in Saudi HEIs.

However, the survey data analysis did not find a statistically significant relationship between the lack of knowledge about blockchain and its adoption in Saudi HEIs ($\beta = -0.062$, $p = .354$). Therefore, the results of the study contradicted the generally established negative link in the literature between these two factors (e.g., Falcone et al., 2021; Post et al., 2018; Wang et al., 2019). One explanation for this could be that while a lack of knowledge about blockchain is generally recognised in the Saudi educational sector, it does not prevent universities from experimenting with it. Indeed, during the interviews, none of the respondents, even those who claimed a drastic lack of blockchain knowledge in Saudi HEIs, actually said that this would prevent their institutions from adopting it. In contrast, the existing empirical studies view the lack of knowledge as a strong preventive factor to adoption. For example, it was claimed that the lack of knowledge causes organisations to postpone its adoption over concerns regarding potential costs and the need for training (Clohessy & Acton, 2019; Sternberg et al., 2021). However, as previously discussed, the majority of Saudi HEIs tend to experiment with new technologies even if they lack substantial expertise in these technologies. With this, they follow well-established technology strategies of their own. Moreover, as reported by the interviewees, Saudi HEIs see no problem in acquiring the necessary resources and specialists for the technologies that are seen to be valuable and beneficial. For these reasons, the absence of the negative link between the lack of knowledge about blockchain and its adoption could be justified.

8.9.2 Privacy and Security Concerns

Concerns regarding privacy and security with novel technologies are nothing new. Because the security of data is of the outmost importance for organisations, the decision makers prefer to rely on the established security mechanisms to ensure high levels of user data safety. Due to its decentralised nature, blockchain is often referred to as a trust-less mechanism (Pandey & Litoriya, 2021). Because it relies on a distributed network to conduct and confirm transactions, no third parties are involved, and no single centralized structure is necessary to its use. All transactions can be conducted from different systems and devices connected to a network (Chen et al., 2018).

And yet, privacy and security concerns are common with blockchain applications. These may be related to the absence of commonly established algorithms and related design components for data safety across multiple blockchains (Holotiuk, Pisani, & Moormann, 2018; Spychiger, Tasca, & Tessone, 2021). In the context of higher education, researchers found that the transparent nature of blockchain may be a perceived threat to user privacy (e.g., Awaji et al., 2020; Ma & Fang, 2020; Pfeiffer et al., 2020; Raimundo & Rosario, 2021). However, in the course of the interviews, it was revealed that the primary reason for privacy and security concerns among the decision makers in the context of Saudi HEIs was the lack of a complete understanding of how blockchain technology works. The results of the survey analysis also confirmed the negative effect of privacy and security concerns on blockchain adoption ($\beta = -0.247$, $p < .001$). Therefore, while supporting the main proposition in the literature that privacy and security concerns may slow blockchain adoption, this study identified a different mechanism for this which is the lack of due understanding of technology. This suggests that even though the lack of knowledge was not established as a direct barrier to blockchain adoption in Saudi HEIs, it may have an indirect influence by enhancing privacy and security concerns about blockchain.

8.9.3 Association with Finance Only

The association of blockchain with finance only is rarely if ever considered as a barrier to its adoption in other industries. However, this factor emerged strongly in the course of this study's interviews. Specifically, the respondents talked about blockchain being associated with cryptocurrencies and its perceived absence of useful applications for education. This may not be a surprising result, however. Originally, the working blockchain technology was implemented as a part of the bitcoin cryptocurrency framework (Nakamoto, 2008). An incredible rally of cryptocurrency values, the creation of cryptocurrency exchanges, and the legalisation of cryptocurrencies as viable payment tools have unquestionably contributed to blockchain interest from a financial perspective. However, blockchain applications outside of cryptocurrency, even successful ones, remain much less exposed to the general public. This has been recognised in most of the literature surveys on blockchain applications in education (Bhaskar et al., 2020; Kamisalic et al., 2020; Ma & Fang, 2020; Raimundo & Rosario, 2021).

The results of the survey analysis confirmed the negative link between blockchain's association with finance only and its adoption in Saudi HEIs ($\beta = -0.494$, $p < .001$). In fact, this was also the strongest barrier to adoption among those investigated. As such, this study demonstrated that a unique factor like association with limited applications could be detrimental to the blockchain adoption process. On a further note, it can be said that such associations also arise from an insufficient understanding of the technology and its principles of work. That said, the lack of knowledge about blockchain once again could play an indirect role in impeding blockchain adoption by establishing preconceived assertions of limited applications among the potential users.

8.9.4 Language Concerns

Language concerns emerged in this study as yet another unique barrier in the blockchain adoption process. Unlike decision makers in English-speaking countries or where English is commonly learned and used, the dominant language in Saudi Arabia is Arabic. Accordingly, decisions regarding innovations are often supported by information available in the native language. The majority of interviewees brought up their concerns about the lack of information about blockchain in Arabic, which would in turn leave it out of the usual technology considerations by the decision makers in Saudi HEIs. Consequently, the main concern by the interviewees was that administrators would feel uncomfortable implementing technologies without thorough descriptions available in their native language. Further, it was argued that the language barrier in blockchain may be a reason for the shortage of good blockchain specialists and, as a result, prevent its timely adoption.

The results of the survey analysis confirmed the negative link between language concerns and blockchain adoption in Saudi HEIs ($\beta = -0.199$, $p = .002$). It appears that a language barrier can be a detrimental factor for blockchain adoption in Saudi HEIs. While such a link appears somewhat unique in relation to blockchain adoption specifically, language as a barrier to technology adoption has been explored in relation to other innovations. Some examples in this regard include mobile payment services, cloud technologies, online education platforms and telemedicine among others (Hiran, 2021; Leng, Gu, & Dalte, 2015; Otieno, Liyala, Odongo, & Abeka, 2016; Rahman & Hoque, 2018). Further, similar observations were reported in the context of Saudi Arabia for such technologies as online healthcare and learning management systems (Alenezi, 2021; Alodhayani, Hassounah, & Qadri, 2021). Therefore, the language barrier for blockchain adoption confirmed in this study supports and further expands the existing literature reports of its negative effect on technology adoption.

8.10 Chapter Summary

This chapter critically discussed the results of the study in the context of the available literature on blockchain adoption both in the education sector and beyond. With 11 out of 16 predicted relationships confirmed by the study outcomes, it can be asserted that the proposed conceptual model had a good predictive power. In most cases, where the relationships were confirmed, the study propositions coincided with the general literature on the topic of blockchain adoption in the context of higher education. The relationships that were not confirmed can be explained by a deeper analysis of the study context. In addition, two specific relationships, namely the language barrier and blockchain being associated with finance only are promising avenues for further research. The next chapter provides the main conclusions following the study findings and proposes theoretical and practical implications arising from the study results.

9 Conclusions and Recommendations

9.1 Introduction

This chapter summarises the key research findings and uses them to draw the main conclusions and recommendations arising from this work. Section 9.2 draws the key conclusions based on the study results. The conclusions are organised to demonstrate the role and effect of each of the five dimensions of the proposed adoption model. Section 9.3 outlines the key theoretical implications of the study. Section 9.4 outlines the major practical implications for HEI administrators and the higher education industry in Saudi Arabia as a whole. Section 9.5 lists the major limitations of the study. Finally, Section 9.6 provides suggestions for future research.

9.2 Main Conclusions

To the best of the researcher's knowledge, this study offered the first attempt to examine blockchain adoption by Saudi HEIs using an integrated DOI-TOE framework. and provided a comprehensive list of factors that could be influential in this process. Importantly, a mixed methods research design applied in the study allowed the effect of these factors to be measured and to also explore the underlying mechanisms of these effects. In other words, the study answered the questions *whether* and *why* with regards to the hypothesised relationships. This, in turn, offers good grounds for both theoretical and empirical implications.

9.2.1 Technology Factors Relevant to Blockchain Adoption

This study explored the effect of five technology characteristics based on DOI (Rogers, 1995). From the results of the study, it is concluded that the three factors relevant for blockchain adoption in Saudi HEIs are *relative advantage, complexity* and *observability* (Table 61).

The underlying mechanism supporting the effect of relative advantage is blockchain's groundbreaking nature which seemingly allows it to replace or supplement a number of existing technologies for the HEIs' benefit. On the other hand, there is recognition that many of the potential advantages still have to be realised in practice in the higher education sector. The underlying mechanism supporting the negative effect of perceived complexity on blockchain adoption is novelty: given the lack of information and use cases, decision makers still perceive blockchain as rather difficult to understand and implement. Finally, the underlying mechanism for observability effect on blockchain adoption is the clarification of value. For decision makers, a higher degree of blockchain visibility means a stronger understanding of how their institutions could benefit from its adoption.

Table 61: Technology Factors Influencing Blockchain Adoption and the Underlying Mechanisms

Technology Factor	Effect on Adoption	Underlying Mechanism
Relative Advantage	Positive	Groundbreaking nature: blockchain enables many technologies used by HEIs to be replaced or supplemented.
Complexity	Negative	Technology novelty: perceptions of it being difficult to understand and implement.
Observability	Positive	Clarification of value: more visibility enables a better understanding of blockchain benefits.

9.2.2 Organisational Factors Relevant to Blockchain Adoption

This study explored the effect of three organisational factors within TOE (Tornatzky & Fleischer, 1990). Based on the study results, it is concluded that *top management support* and *organisational readiness* are influential for blockchain adoption in the context of Saudi HEIs (Table 62). Further, the effect of both factors was similar in strength thereby suggesting the equivalent importance of both. The underlying mechanisms for top management support are usually seen through overcoming the adoption barriers, creating a technology vision, and enabling sufficient resource allocation for new innovations (Lustenberger et al., 2021). In the case of Saudi HEIs, additional supporting mechanisms are strong vertical hierarchy and the top-bottom decision process. With regard to organisational readiness, the supporting mechanisms for blockchain adoption are the presence of a combination of technological, human and financial resources.

Table 62: Organisational Factors Influencing Blockchain Adoption and the Underlying Mechanisms

Organisational Factor	Effect on Adoption	Underlying Mechanism
Top Management Support	Positive	Overcoming adoption barriers and enabling resource allocation via strong hierarchy and top-bottom decision making.
Organisational Readiness	Positive	Presence of sufficient technology, human and financial resources to support adoption.

9.2.3 Environmental Factors Relevant to Blockchain Adoption

This study explored the effect of three environmental factors within TOE (Tornatzky & Fleischer, 1990). Based on the study results, it is concluded that *existing regulations* and *government support* are influential for blockchain adoption in the context of Saudi HEIs (Table 63). The primary mechanisms responsible for the positive relationship between existing regulations and blockchain adoption are context specific: 1) there is less uncertainty regarding blockchain regulation; 2) there is generally a rather vibrant and conducive legal framework for emergent technologies in the country; and 3) Vision 2030 policies create very lenient framework for blockchain adoption. As for government support, focus on innovative online technologies in education and support is seen as the primary driver.

Table 63: Environmental Factors Influencing Blockchain Adoption and the Underlying Mechanisms

Environment Factor	Effect on Adoption	Underlying Mechanism
Existing regulations	Positive	Low legal uncertainty and favourable Vision 2030 policies.
Government support	Positive	Focus on development of innovative technologies in online education.

9.2.4 Education Quality Factors Relevant to Blockchain Adoption

Two education quality factors were considered to influence blockchain adoption. Reducing student unemployment was found to be the only relevant factor for Saudi HEIs. Once again, this factor is context-specific issue for Saudi Arabia's education as the rate continues to hover around 28%, with over half of the unemployed holding at least a bachelor's degree (O'Neill, 2022). Accordingly, two mechanisms that link a potential reduction in graduates' unemployment to blockchain adoption in Saudi HEIs are: 1) establishing accelerated, easily verifiable system of learning credentials and certificates; and 2) by creating job opportunities across the blockchain system itself in such fields as engineering, software development, education, administration and related fields.

9.2.5 Main Barriers to Blockchain Adoption

Four potential barriers to blockchain adoption were identified in this study. Based on the study results, three are relevant to blockchain adoption in Saudi HEIs: *privacy and security concerns*, *association of blockchain with finance only*, and *language concerns*

(Table 64). The underlying mechanism for privacy and security concerns, which negatively affects the adoption of blockchain in Saudi HEIs, is a lack of a thorough understanding of how blockchain technology works. In the same manner, it can be concluded that the lack of such a thorough understanding plays an important role in the negative relationship between blockchain's perceived association with finance only and its adoption in Saudi HEIs. Finally, the negative link between language concerns and blockchain adoption in Saudi HEIs is underscored by the perceived lack of complete information about blockchain in Arabic. This is another unique contextual factor identified in this study.

Table 64: Barriers to Blockchain Adoption in Saudi HEIs

Barrier	Effect on Adoption	Underlying Mechanism
Privacy and security concerns	Negative	Lack of thorough understanding of blockchain.
Association with finance only	Negative	Lack of thorough understanding of blockchain.
Language concerns	Negative	Absence of sufficient information about blockchain in Arabic.

9.3 Theoretical Implications

This study applied an enhanced DOI-TOE framework to investigate blockchain adoption in Saudi Arabia HEIs. Both DOI and TOE offer solid theoretical foundations and frameworks to study innovations as they diffuse through societies and populations. The current research adds to the existing literature testing TOE extended models and the more specific TOE-DOI to study blockchain adoption (e.g., Barnes & Xiao, 2019; Clohessy et al., 2020; Ullah et al., 2020). The following theoretical contributions are provided by the study:

- *Confirmation of the Science Design approach for blockchain adoption modelling*: the Science Design approach for modelling blockchain adoption process in higher education was successfully confirmed in this study.

- *Confirmation of enhanced TOE-DOI framework viability*: the results of the study demonstrated that an enhanced TOE-DOI framework is a viable tool to study blockchain in Saudi HEIs with the results of most hypotheses tests aligning with the existing literature findings. As such, the study confirmed the application of these theories in a new context.

- *Importance of the contextual factors confirmed*: the study demonstrated that TOE-DOI can be extended to account for unique context characteristics. On the one hand, this confirmed the framework's flexible nature; on the other hand, it supplemented the existing theoretical knowledge by testing the key propositions of TOE and DOI in a new model. As such, the study once again demonstrated that the factors missing or not accounted for in either framework should be added to the analysis for a more comprehensive view on adoption.

- *Validity of the proposed model confirmed*: the majority of the relationships within the proposed framework of blockchain adoption were confirmed. Therefore, the framework can be considered a good theoretically supported foundation for the future studies of blockchain adoption in the context of Saudi HEIs. It filled the existing gap in knowledge in the absence of such a framework.

- *Validity of the blockchain adoption instrument confirmed*: the study offers a validated instrument to study adoption either through a combination of the considered factors or test the effect of each dimension more thoroughly. Overall, the researcher finds DOI and TOE excellent theoretical foundations to study blockchain adoption at an organisational level in Saudi organisations and specifically to explain the phenomenon of blockchain adoption in Saudi HEIs.

9.4 Practical Implications

The existing literature suggests that blockchain adoption in higher education is lagging behind other sectors such as, for example, supply chain management, healthcare or finance. This was also confirmed in the course of the interviews with the higher education and IT professionals. As such, studies such as this could help increase the overall awareness of the potential of blockchain in higher education and how it can be realised in practice to benefit both HEIs in Saudi Arabia and the education sector as a whole. The major practical implications arising from this study are:

- *Offering a good initial understanding of the blockchain adoption process in Saudi HEIs*: The intense interest in blockchain technology arguably brings as much excitement as speculation about its uses and applications in higher education. As such, a good understanding of the topic is necessary for a prudent approach to blockchain adoption by institutional decision makers. The framework of adoption presented and tested in this study can serve as a good starting point in this process.

- *Offering the first-of-its-kind practical model of blockchain adoption in Saudi HEIs*: to the best knowledge of the author, this was the first study of its kind to empirically explore the combinatory effect of technological, organisational, environmental and quality factors on and barriers to blockchain adoption in Saudi HEIs. It can serve as a foundation for developing a tool to guide HEI organisations and, perhaps, the industry as a whole on whether, when and how the adoption process should proceed.

- *Model flexibility and modularity*: the proposed blockchain adoption model conveniently organises the important factors that impact blockchain adoption in Saudi HEIs into several dimensions. The decision makers can assess the influence of each dimension and the variables it comprises before making a decision regarding blockchain adoption and during the implementation process.

- *Relative importance of factors and dimensions*: not all of the predicted relationships were confirmed by the study results. However, the absence of statistically significant relationships may not necessarily indicate the absence of any effect whatsoever. It could be argued that the factors that did not exhibit a relationship to blockchain adoption were simply regarded as less important in the early stages of the blockchain adoption process, since this is the current stage in Saudi HEIs. This could change as blockchain becomes widely diffused in the industry. In fact, DOI (Rogers, 2003) assumes that certain technology attributes are more important than others at different adoption stages of innovation diffusion. For example, relative advantage and complexity could be more important at the early stages of innovation diffusion when the technology is new, and the decision makers must see its benefit clearly. At the later stages, however, compatibility could become more important as organisations will need to make cost-benefit decisions regarding the innovation implementation. The same logic applies to TOE (Tornatzky & Fleischer, 1990). For example, the influence of environmental factors could increase or decrease if blockchain regulations become stricter or more lenient.

- *A validated assessment tool for blockchain adoption and the factors that underlie the process*: while created specifically for blockchain applications for school certificates, the tool can be used to determine the external and internal influences on the blockchain adoption process so that targeted decisions can be made to act on them.

9.5 Research Limitations

This study has a number of limitations which should be mentioned and taken into account when considering the study results. These limitations are based on the study geography, context and the chosen methodology:

- *The study was geographically limited to HEIs in Saudi Arabia*. The findings of the study, therefore, should be treated with caution in other national contexts. Similarly, the presented conceptual framework may need to be adjusted by researchers in other countries, especially with regard to the context factors presented and explored. Arguably, both the findings and the framework might be more applicable in countries with similar educational structures, technology-related jurisdictions, language and national culture. Specifically, these are the Arab countries of the Gulf such as Kuwait, UAE, Bahrain, Oman and Qatar. Still, it is expected that at least some of the factors identified within DOI and TOE should be applicable to explore blockchain adoption in other countries' contexts since the effects of the variables confirmed in this study are very similar to studies conducted in other countries.

- *The study focused on higher education sector specifically*. Industry-specific findings of this study should be approached with caution when extrapolated to other sectors. The specifics of technology adoption may vary in different industries and therefore some factors may be less relevant while new factors may emerge. For example, this study introduced an industry-specific education quality dimension which may be less important for other industries and sectors. Further, while the factors of adoption within both DOI and TOE are considered universal for all forms of innovations, they have demonstrated different degrees of strength for various innovations. A logical decision for researchers who decide to take this framework as a basis for other industry research would be to determine the stage of technology adoption in question. A better match would be those contexts where blockchain is relatively new, as is the case with blockchain in the higher education sector.

- *The study explored a specific blockchain application: school certificates*. The reason for this was explained in Section 6.6: following the interviews, it was determined that blockchain certificates are the only viable application of the technology in Saudi HEIs. However, the literature mentions other working and prototype applications for blockchain in education: student identity management and solutions, cryptopayments, novel learning platforms, intellectual property protection, administrative cost reduction, institution accreditation and academic publishing platforms (Capece, Ghiron, & Pasquale, 2020; Fedorova & Skobleva, 2020; Haugsbakken & Langseth, 2019; Jirgensons & Kapenieks, 2018; Kamisalic, Turkanovic, Mrdovic, & Hericko, 2020). These applications may be driven by other types of factors or the role of the explored factors in this study may differ for them.

- *The study had a cross-sectional design*. The research was performed on cross-sectional data and represented a specific point in time. While demonstrating the current state of the nature of the blockchain adoption phenomenon in Saudi HEIs, it does not offer information on how the phenomenon develops. Further, according to Rogers (2003), the degree of significance of the factors may change as the diffusion progresses. The same is true for the TOE factors (Tornatzky & Fleischer, 1990). Therefore, as the diffusion of blockchain progresses in higher education, the presented framework may require re-visiting and re-evaluation.

- *The study participants might not have had the best knowledge of blockchain*. Given the early stage of blockchain diffusion in Saudi HEIs, it is unlikely that all the decision makers had a thorough knowledge of the technology and its potential benefits. The interviews, for example, demonstrated that only half of the participants had a good degree of knowledge about blockchain and could confidently speak of its existing applications and benefits. It is quite possible then that relatively large number of the participants of the large-scale survey did not possess high degree of blockchain knowledge and applications in higher education. As such, the strength of some factors in the framework may not be fully indicative of the real state of matters related to blockchain adoption in Saudi HEIs.

It can be seen that some of the limitations presented above arose from the study's focus while others were addressed to the best ability of the researcher. Therefore, the described limitations are unlikely to diminish the quality of the research. Rather, some of them present new avenues for research which, the researcher hopes, will be addressed in future studies.

9.6 Future Research

Due to the exploratory nature of this study, a number of interesting and important avenues for future research arise based on the study findings and limitations:

- *Further model clarification*: the relationships explored in this study may require further analysis and confirmation. This may be done by drawing from larger samples, clarifying factors' operationalisations and investigating the relationships in more detail.

- *Further clarification of factors:* for example, the role of organisational readiness as a composite factor stimulating blockchain adoption in Saudi HEIs can be clarified. This study treated organisational readiness as a combination of financial, human and technology resources sufficient for adoption. However, this may not be a comprehensive list of factors. Others may include alignment with organisational strategy or competitive model or network incentive structures, among others (Clohessy et al., 2020).

- *Clarification of unexpected results:* for example, the existing regulations surprisingly demonstrated a positive impact on adoption in this study. The respondents may have attributed such optimism to the Vision 2030 policies that are very lenient in relation to technology innovations of various kinds. It would be, therefore, useful to examine the specific aspects of existing regulations in Saudi Arabia and identify which ones provide such confidence for potential organisational adopters of blockchain.

- *Clarification of the role of knowledge:* while knowledge was not established as a direct barrier to blockchain adoption in Saudi HEIs, its indirect effects could be plausible given that, for example, many respondents did not understand the underlying mechanisms of blockchain and, therefore, considered it a threat to privacy and security. Likewise, the lack of knowledge about blockchain could play an indirect role in impeding blockchain adoption by establishing preconceived assertions of limited applications among the potential users.

- *Exploration of additional individual and factors:* As Awa et al. (2017) argued, even in organisational settings, the onus of the decision making remains on individuals. Their decision regarding technology could be somehow influenced by attitudes towards it, their perceptions of how it could fit with certain tasks related to HEI administration and service provision and to what extent they believe blockchain would be easy to implement and use. As discussed, such factors are available in TRA, TPB, TAM and TTF theories. Granted, adding individual- and task-related factors could increase model complexity. On the other hand, this could also offer new insights about blockchain adoption in higher education. At the same time, this study demonstrated the importance of contextual factors in blockchain adoption.

- *Exploration of additional contextual factors*. Despite a comprehensive list of factors explored in this study, additional contextual variables could have been inadvertently omitted. For example, the extent to which blockchain adoption benefits students in terms of job opportunities, whether early adopters or not, can depend on various contextual factors, including the level of implementation, support systems in place such as graduates with a blockchain qualification, and the job market's readiness for blockchain-verified credentials. Acknowledging these contextual nuances can lead to a more informed decision making for HEIs' management. Therefore, exploring additional contextual factors at various levels could also help enhance the adoption framework.

- *Testing the model in new settings:* As previously mentioned, the framework could fit national settings which are similar to Saudi Arabia in terms of culture, structure of educational sector, language and technology related jurisdictions. It would be useful to test these assumptions empirically. It could also be useful to conduct comparative studies to identify which factors are stronger in countries with differences in culture and higher education sectors. Further, this study considered higher education institutions only. The model could be tested in other educational institutions, such as K-12. Finally, the study did not distinguish between different types of blockchain. The three major types of blockchain are permissionless, permissioned and hybrid (Tapscott & Tapscott, 2016). Due to the differences between the three, their adoption process and factors may differ as well. This represents another potential research direction. Finally, research could explore whether the model holds for different applications of blockchain in education and whether the role of the factors varies in strength across them.

- *New approaches to evaluate the model:* the cross-sectional design of this study allows the factors influencing blockchain adoption to be evaluated at this point of time, under the existing conditions. The role and strengths of the factors within the framework could change as blockchain diffuses further among the HEIs. For example, some interview participants in this study argued about the ability of blockchain to provide employment benefits to all students and not to early adopters only. Some also argued that peer pressure could become more significant as blockchain further penetrates the higher education sector and its benefits become more visible. As such, it would be useful to re-visit the framework at later stages of the adoption process as described within the DOI (Rogers, 2003). Even better evidence could be provided by employing a longitudinal research design to study blockchain adoption in Saudi HEIs which could help observe changes in the factors' dynamics as the occur.

9.7 Chapter Summary

This chapter provided the major conclusions arising from the research, drew implications from the findings and proposed directions for future research. The mixed research method applied in the study allowed both the relationships between various factors of blockchain adoption and its adoption in Saudi HEIs and the mechanisms supporting those relationships to be uncovered. These were summarised in this chapter. Further, the study demonstrated the applicability of the key theoretical frameworks, DOI and TOE in combination to explore blockchain adoption in the new context of Saudi HEIs. The developed framework that distinguished technology, organisational, environment and quality factors as well as barriers could serve as a basis for future research on blockchain adoption. Since the framework is both theoretically supported and flexible, it can be modified and adjusted to meet the requirements of other contexts. The results of the study also offer a good initial map for decision makers outlining the important internal and external factors that matter in the blockchain adoption process.

The chapter outlined several important limitations that should be considered alongside the research findings. These are based on the study geography, context and the chosen methodology. Considering these limitations, several directions for future research were identified: 1) applying the study framework in different national and sectoral contexts; 2) refining the framework by clarifying and adding/removing certain factors; 3) clarifying the role of the existing factors; and 4) observing possible changes to the factor roles at different stages of the diffusion process.

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