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Adoption of embedded subscriber identity module (ESIM) technology services by South African smartphone users for international roaming

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ABSTRACT

The objective of this study was to investigate the factors that influence the intention to adopt ESIM (embedded SIM) technology for international roaming services by South African smartphone users.

Currently, the Subscriber Identity Module (SIM) is a physical hardware with an integrated chipset that is inserted into mobile handsets. Physical SIM cards allow a single profile to be provisioned for users. The next evolution in SIM card technology, ESIM, have the capability to support multiple user profiles.

The development of services and new business models enabled through ESIM technology is dependent on the willingness of users to adopt these services.

A theoretical model was developed using TAM as a basis with the additional constructs of trust and risk to test the intention to adopt international roaming services. A cross-sectional, quantitative study using an online survey instrument was employed. A sample size of 142 was collected. The sampling method used was a non-probability, convenience sampling technique and Confirmatory Factor Analysis (CFA) was performed to examine the reliability and validity of the measures and the main conceptual model was tested using structural equation modelling (SEM).

Perceived ease of use and perceived usefulness were identified as the most significant factors that influence the intention to adopt ESIM roaming services. Perceived usefulness was identified as significant mediating variable between perceived ease of use and intention to adopt. Perceived risk presented as statistically significant, direct influences on intention to adopt. The trust factor had an insignificant influence of the intention to adopt.

The study's findings form a basis for future research on ESIM enabled services. These findings are relevant to mobile operators, technology platform owners and developers of services for ESIM enabled devices (smartphones, wearables and internet of things devices) with the intent to understand factors that drive users' intention to adopt services.

KEYWORDS

Embedded Subscriber Identity Module; ESIM; international roaming; technology adoption model; TAM, trust; perceived risk; smartphones; mobile phones; perceived ease of use; perceived usefulness

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LIST OF ACRONYMS

5G – Fifth Generation

CFA - Confirmatory Factor Analysis

Email – Electronic Mail

E-services – Electronic Services

ESIM – Embedded Subscriber Identity Module

ETAM – Electronic Services Technology Adoption Model

M-commerce – Mobile Commerce

MNO – Mobile Network Operator

MSISDN – Mobile Station International Subscriber Directory Number

MVNO – Mobile Virtual Network Operator

OTA – Over the Air

SEM – Structural Equation Modelling

SIM – Subscriber Identity Module

TAM – Technology Acceptance Model

TAMM – Technology Acceptance Model for Mobile services

TRA – Theory of Reasoned Action

1 INTRODUCTION

1.1 Statement of Purpose

This research is a quantitative study to investigate the intention to adopt embedded subscriber identity module (ESIM) technology services by South African smartphone users for international roaming.

1.2 Background of the Study

The background study presents subscriber identity module (SIM) technology and the digitisation of SIM cards to ESIM, the relevance of the services that this technology enables, the current prevalence of smartphones and ESIM smartphones and the ESIM services currently offered by the major South African mobile network operators (MNO).

Subscriber Identity Module (SIM) is a physical hardware with an integrated chipset that is inserted into mobile handsets. The software on the SIM cards enables mobile network operators to identify users, authenticate profiles and provision services to the handset. Mobile users are hence able to securely request and utilise the mobile network subscription services (Koshy & Rao, 2018). Physical SIM cards are specific to mobile network operator.

As handsets have evolved the size of the SIM card have decreased to enable more space on the handset for higher processing speeds. The latest evolutionary stages in SIM card technology are devices with embedded SIM cards (ESIM). The SIM cards are integrated into the smartphone hardware (Koshy & Rao, 2018). The integrated chip set provides enhanced levels of security to the devices (GSMA, 2021a).

The fifth generation (5G) mobile networks support high data speeds up to 20 Gigabits/seconds (Qualcomm). Device manufactures require additional space on devices to enable these high speeds. ESIM technology occupies a smaller space on the hardware allowing more area for other processing components. To support

the high data speeds, the new generation of smartphones and wearables are manufactured with ESIM technology (Koshy & Rao, 2018).

The relevance of this technology, in this study, is that it enables ESIM smartphones to support multiple user profiles (from multiple MNO) simultaneously with the limitation of the number of active profiles at a time. Mobile users can be provisioned over the air (OTA) interface without the need for physical interactions with an individual MNO. Currently, mobile users purchase physical SIM cards which are inserted into slots in handsets or other devices. Provisioning occurs when customers contact the MNO and activate their profiles. ESIM mobile users have the capability to authenticate, provision and seamlessly switch services between multiple MNO without the limitations of switching physical SIM cards. This makes users operator agnostic as they can access services from multiple networks, if the MNO profile is provisioned (GSMA, 2018).

The ESIM technology will enable devices (tablets, laptops and wearables) to provision and connect directly to any available mobile networks without the need for an additional mobile device or broadband connection. The research in this study will focus on smartphones. Currently, in South Africa 64,1% of all internet users access the internet through mobile networks (ICASA, 2022). ESIM devices may contribute to the increase in access to the internet.

Globally, it is forecasted that there will be 2.4 billion smartphones with embedded SIM technology by 2025. This figure will represent 33% of all smartphones active on mobile networks (GSMA, 2021b).

In the SADC region, smartphone adoption is forecasted to rise to 68% of users, with 6% of users having access to a 5G networks by 2025 (GSMA, 2021c), enabling faster data speeds. In South Africa, as reported in September 2021, there are 65,3 million smartphones subscriptions out of the total mobile subscriptions of 103,1 million. This reflects 63,3% of all mobile phones in use (ICASA, 2022). The trend indicates a rise year on year of the total number as forecasted in the SADC report. Currently all major smartphone manufactures (Apple, Samsung, Google, Oppo, Motorola, Microsoft Duo, Huawei) have built

their latest models with ESIM technology integrated into the chipsets (OASIS, May 2021).

In South Africa, the leading mobile operators MTN, Vodacom and Telkom have all launched offerings supporting the ESIM capability. MTN and Vodacom have further extended their ESIM product portfolios to include wearables (smart watches) (Web, 2021).

1.3 Research Problem

The Global Systems for Mobile Communications (GSMA) defines international roaming as:

"International mobile roaming is a service that allows mobile users to continue to use their mobile phone or other mobile device to make and receive voice calls and text messages, browse the internet, and send and receive emails, while visiting another country" (GSMA, 2012).

The service, currently available to South African international roamers, is for users to register with their MNO and obtain an approval to roam. The users continue to use their Mobile Station International Subscriber Directory Number (MSISDN) number and are billed by their local MNO based on rates determined by commercial agreements between local MNO and visiting MNO. Users have limited transparency on the structure of the charges. Charges are billed to the users as per agreed financial contracts (monthly billing cycles for contracted users, credit cards/e-wallets for prepaid users). The technical quality of service provided to visiting mobile users are defined and limited to the services provided by foreign MNO in the technical and commercial contracts (GSMA, 2012). The access to the international roaming services, quality of service, cost of the service and the foreign MNO used are controlled for South African mobile users.

The technology of physical SIM cards, with respect to the number of profiles that can be stored on a single SIM is an inhibitor to the access to international roaming as an independent service to mobile users (Gerpott & Ahmadi, 2015).

The technology inherent in ESIM smartphones has the potential to change the business model for international roaming service for users and MNO through the disruption in the existing value chains. The disruption is emerging from platform providers and device manufacturers as mobile virtual network operators (MVNO). ESIM users in the United States of America are offered international roaming through this platform model. Google Project Fi currently provides international roaming services to over 140 countries for ESIM enabled smartphones, through partnerships with local MNO. Users access services, on demand, through the platform, download profiles, activate payment methods and are ready to use foreign MNO services on arrival at multiple destinations (Sehgal & Dutta, 2020).

The disruption may emerge from handset manufacturers, existing platform technology providers and new entrants who will look to disrupt on the opportunities available by ESIM technology. The digitisation of SIM cards creates an ecosystem where mobile services, traditionally provided by MNO, can be provided as e-services by platform providers. For MNO, the technology maturity of ESIM services can enable new business opportunities through disruption in existing value chains (Evans, 2017).

The development of services and new business models enabled through ESIM technology is dependent on the willingness of users to adoption these services.

The research proposal is hence to test the intention of customers to use the services enabled through ESIM smartphones. The focus of the research is to explore the factors that drive the intention of South African users to use international roaming services on ESIM smartphones.

1.4 Research Question

In the context of opportunities that exist due to ESIM enabled devices, insufficient information exists on factors that will drive the intention to use an e-service traditionally provided by MNO as a mobile service. It is the understanding of user intentions and factors that influence their decisions that drives this research. The research question is:

What are the factors that affect the willingness to adopt international roaming services enabled by ESIM smartphones?

1.5 Rationale

This study is valuable because the inherent characteristics of the ESIM technology will further drive the digitisation of user engagements with MNO and decrease user dependence on single MNO for mobile services. Users will be enabled to provision profile remotely and store multiple profiles on a single device. The users will not be encumbered by a physical SIM when selecting the active profile for use (ITU, 2022).

ESIM technology is available on laptops, wearables, and smartphones. This enables the connection directly to data networks without an intermediary connection and will contribute to the increase of access to digital services. As the ESIM technology propagates and cost to produce decreases, more devices will become available to users (democratisation). The existing value chain of incumbent MNO players may be disrupted as customers have the freedom to seamlessly switch operators (GSMA, 2018).

ESIM technology enabled devices may improve the accessibility to technology networks and could contribute to addressing the digital divide through access to information and communication.

The study is expected to contribute to the knowledge of technology adoption by users of services enabled through ESIM technology. The intention to use and actual use has the potential to disrupt incumbent players in the South African mobile industry. New entrants have opportunities to design and launch

communication services for voice and data enabled by ESIM technology as MVNO providers through platform service providers.

The findings from this study can be extended to other emerging markets, with similar characteristics to South Africa, with respect to the demographics (income, education level, smartphone adoption, availability of ESIM devices).

1.6 Delimitations of the Study

The study will be focused on

I. all mobile users - experienced, novice and inexperienced international roaming service users.
II. smartphone users with an active subscription (pre-paid or post-paid) on any one of the South African mobile networks (Vodacom, MTN, Cell C, Telkom).
III. the intention to adopt by users based on their perceptions of ESIM technology from existing exposures and the introductory video information provided in the survey.

The following is excluded from the study:

I. wearables, tablets and laptops or any other device with integrated ESIM technology.
II. impact of ESIM on the incumbents in the South African mobile operators
III. users' experiences of quality, efficiency, and effectiveness of current international roaming services.
IV. existing access to roaming services (pre-paid SIM cards from international destinations) outside of the services provided by local MNO.

1.7 Definition of Terms

ESIM technology refers to devices where the SIM cards are integrated into the smartphone hardware (Koshy & Rao, 2018).

International roaming services are employed by mobile users when travelling internationally. The users have access to all voice, messaging and data services that are available on the roaming network. Users are billed at rates contracted by their MNO and the roaming network (GSMA, 2012).

Risk refers to threat to the user of economic, personal and privacy information (Pavlou, 2003).

Trust refers to the ability of the service provider and the enabling technology to provision and provide the services requested by the mobile user (Mou, Shin, & Cohen, 2017).

1.8 Assumptions

It is understood that the international roaming service is a limited use case for ESIM technology. International roaming services have a limited number of users with approximately six hundred and fifty thousand South Africans having travelled in December 2019, prior to the COVID-19 pandemic (StatsSA, 2020) when international travel for leisure was at a peak.

The actual adoption of ESIM services will be dependent on proliferation of mobile smartphones and other devices with the technology. User awareness of ESIM has been identified as a major obstacle to adoption of services (GSMA, 2021b).

The research approach assumes that the participants of the survey have a basic understanding of technology trends with respect to SIM cards and international roaming.

1.9 Chapter Outline

The chapter outlines the evolution of SIM card technology and the opportunities that the ESIM technology enables for users, MNO, and platform providers. ESIM technology enables new models for the delivery of electronic services traditionally provided by MNO through the capability of ESIM devices to support multiple profiles. South African mobile users of the current international roaming services

offering are governed by the commercial agreements between their MNO and foreign operators. The research investigates the intention of mobile users to adopt ESIM technology for international roaming services.

2 LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

The objective of the literature review is to study a relevant technology adoption model to test the intention to adopt ESIM services for international roaming. The constructs for survey are identified and the hypothesis are formulated. This chapter contains the constructs and relevance in the context of mobile services and e-services, the subsequent hypothesis to be tested with the constructs and the relevant adoption models that predict user intention to adopt technology services.

2.2 Background Discussion

Digital platform ecosystems consist of services, content, platform owners, external producers, and consumers. The platform owners do not own core physical assets (mobile network infrastructure) but rather enable transactions for content and services between participants of the ecosystem. Digital platforms are hosted on cloud based infrastructures which enables the sharing of data across multiple systems and devices (Constantinides, Henfridsson, & Parker, 2018).

Today, mobile users have the option to consume services from multiple platform providers. Services are available through operator-based platforms that are managed by MNO, device-based platforms managed by device manufactures (Apple) and service-based platforms manage by large technology players (Google, Facebook, Microsoft). A major concern for both users and platform owners is privacy and security (digital trust) of both personal and financial information shared (Ghazizadeh, 2012). As the convergence between MNO, service platforms and technology platforms evolve, opportunities exist for each to offer services provided by traditional telecommunication providers (Constantinides et al., 2018). All three of the platform models have the potential

to develop and support multiple profile services enabled through the ESIM technology.

Digital trust is a key contributor to exponential adoption of platform models for delivery of digital services. Trust factors include that users of digital services are protected from cybersecurity risk, can successfully procure and use the services when required and that all the contractual rights with respect to quality of service and costing are adhered to. These three factors are “security, identifiability and traceability” (Mattila & Seppälä, 2016).

2.3 Factors that Affect the Intention to Adopt International Roaming Services Enabled by ESIM Smartphones

The constructs proposed, to address the research question, are trust (TT), perceived risk (PR), perceived ease of use (PEOU), perceived usefulness (PU) and intention to use (BI).

2.3.1 Trust

The model for the provision of e-services, creates a physical distance between users and the providers of ESIM services. In South Africa, international roaming services are provided by MNO. The ESIM service model allows for the service provider to be an online entity. Online entities cannot be physically authenticated by users or regulators and hence may participate in unfair practices and lack of accountability to provide services as contracted. The trust construct address the ability and competence of the service provider to provision and provide the services requested by the mobile user (Mou et al., 2017). Mou et al. (2015) state, “Trust is important to all forms of social exchange and buyer-seller transactions and reflects a consumer’s belief that favourable conditions exist to facilitate transaction success” (p. 3).

Hypothesis 1
H1: Trust is positively related to intention to use ESIM roaming services.

2.3.2 Perceived Risk

Perceived risk influences user behaviour (Jarvenpaa, Tractinsky, & Vitale, 2000). In the e-services’ environment the risk to users can be economic, personal or privacy (Pavlou, 2003). The economic risk relates to the financial information (correct billing, credit card details and banking institutional information). The personal risk is to the user, as they travel abroad and have access to roaming services that compromises their privacy and their financial information. The privacy information relates to the cybersecurity threats to personal information which occurs due to compromised security and malicious activity (firewall breaches, decryption of security protocols, malicious national state actors). The

user intention to consume e-services is higher when the risk arising from privacy and confidentiality is perceived as being low (Taherdoost, 2017).

In a study in the European Union (EU) context in 2014, the construct of risk (inaccurate billing, lack of transparency in pricing) was identified as a negative impact on the intention to adopt international roaming services (Gerpott & Ahmadi, 2015).

Hypothesis 2
H2: Perceived risk is negatively related to intention to use ESIM roaming services.

2.3.3 Perceived Ease of Use

Perceived ease of use is a construct of Technology Acceptance model (TAM). The construct refers to “the degree to which a person believes that using a particular system is free from effort” (Davis, 1989). In the context of this research, this construct is an indicator of the degree of ease to use the international roaming service when the service is requested using the ESIM multiple profile capability.

Hypothesis 3
H3: Perceived ease of use is positively related to use of ESIM roaming services.

Hypothesis 4
H4: Perceived ease of use of the ESIM international roaming service is positively related to perceived usefulness.

2.3.4 Perceived Usefulness

Perceived usefulness is a construct of TAM. Perceived usefulness is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis, 1989). In the context of this study, this construct is the degree that users of ESIM enabled smartphones, believe that the ESIM technology will provide an improved international roaming service.

Hypothesis 5
H5: Perceived usefulness is positively related to intention to use ESIM roaming services.

2.3.5 Intention to Use

The TAM states that the perceived ease of use and the perceived usefulness of technology is a predictor for intention to use and subsequently the use of the technology (Chen, Shing-Han, & Chien-Yi, 2011). The relationship between the intention to use and the adoption of technology is the basic concept of user acceptance models (Viswanath, Morris, Davis, & Davis, 2003). The dependant variable, intention to use will be a predictor to the willingness of users to adopt international roaming as an ESIM enabled service.

2.4 ANALYTICAL FRAMEWORK

2.4.1 Theoretical Framework

In the theoretical framework the discussion outlines the technology acceptance models used to determine the constructs of the research. The relationship between the constructs and predictor of intention to use will be discussed in the context of existing e-services and mobile services.

The intention to use technology and actual adoption of technology can be postulated through the application of many models with various constructs and relationships between the constructs. The fundamental concept in all models is initiated by testing users' perceptions to using a technology. The users' perceptions influence their intention to use, and this can predict the actual use of technology. As a feedback loop the actual use of the technology influences user perception and future use of the technology (Viswanath et al., 2003).

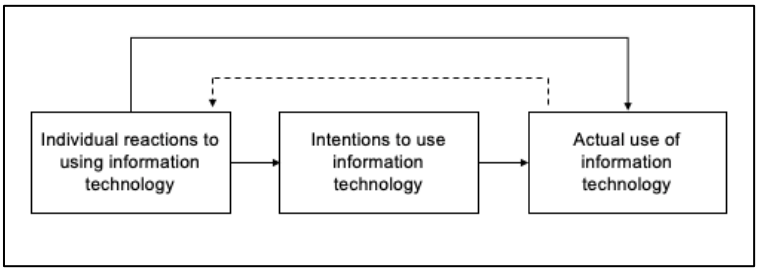


Figure 1 Basic Concept Underlying User Acceptance Models (Viswanath et al., 2003)

2.4.1.1 Technology Acceptance Model (TAM)

The TAM states that a user's intention to use a technology (accept, reject, non-committal) can be statistically predicted by the constructs of perceived usefulness and perceived ease of use.

"Perceived ease of use refers to degree to which a person believes that using a particular system is free of effort. Perceived usefulness refers to the extent that a user believes that a system will help them perform their jobs better" (Davis, 1989).

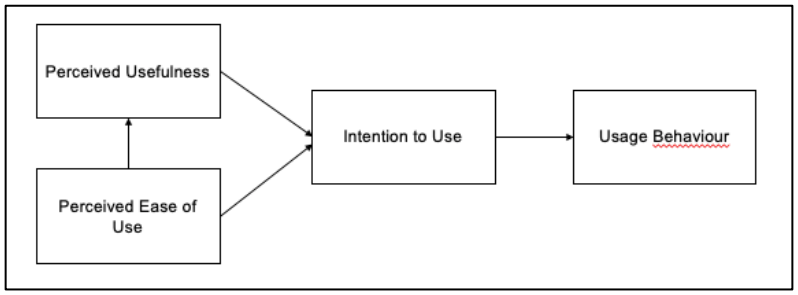


Figure 2 Technology Adoption Model Conceptual Framework (Davis, 1989)

While the TAM has its' origins in the information systems adoption, the model remains one of the most widely models in technology adoption studies (Serenko, Bontis, & Detlor, 2007). TAM has been extended for use in empirical studies to predict user intention for mobile services and e-services.

While TAM is widely used in the prediction of technology adoption, the probability of use of the system can be improved by the inclusion of constructs relating to the specific context relating to human factors and the social context of technology under study (Legris, Ingham, & Collerette, 2003).

Due to the nature of e-services providers being virtual, trust and risk from personal privacy and transaction security impact the intention to adopt e-services. Perceived risk and trust, as an added construct to TAM, have indicated in prior research an impact in the intention to adopt M-commerce, E-payment and platform based e-services (Wu & Wang, 2005),(Lai, 2017),(Bart, Shankar, Sultan, & Urban, 2005), (Jarvenpaa, Tractinsky, & Saarinen, 1999).

To further support the inclusion of the additional constructs of perceived risk and trust with TAM, two additional models were considered for this study. The ETAM (E-services for TAM) model proposed by Taherdoost (2017) uses TAM with the additional constructs of satisfaction, security and quality to predict the adoption of e-service technology. The TAMM (TAM for mobile services) proposed by Kaasinen (2000) uses value to the user and trustworthiness as additional constructs to the TAM model (Kaasinen, 2009). The models stated are not used in this study as the focus for both is to guide the provider of services on design of new services. The intention to use and adoption by users of the ESIM international roaming service are the focus of this study.

The research instrument in this study follows the TAM model with the additional constructs of trust and perceived risk. The model has been tested in a previous study by Pavlou (2003) to test user acceptance of e-commerce. The instrument was selected as it was tested in an exploratory study, refined, and subsequently in a confirmatory study with validation of the hypothesis statements (Paul, 2003).

This study uses TAM, perceived risk and trust to understand the intention to adopt international roaming services enabled by ESIM technology.

2.4.1.2 Trust and Risk

In situational studies, user engagements indicate that the higher perceived risk, the higher the degree of trust is required from users to engage in this behaviour (Koller, 1988). The implication for this research is that if users of the E-SIM roaming services perceive the service as being high risk, the user must adopt a high level of trust to use the service.

The intention to adopt the E-SIM international roaming service is based on research participants subjective and cultural norms as the service is currently not available in South Africa.

Mou et al. (2015) in their research explored the influence of risk and trust in consumer acceptance of e-services. Their effort reviewed sixty-seven empirical studies in the acceptance of e-services, risk and trust. The finding is that the constructs of risk and trust and the effect on intention and acceptance are at variance in each of the models used. The findings are listed below.

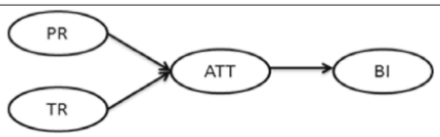
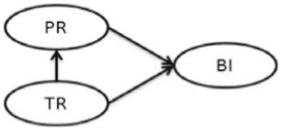
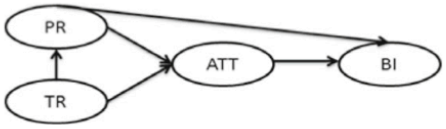
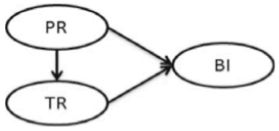
Trust and Risk as Independent Predictors	 Bianchi and Andrews (2012) model. Variations of this model include Lee (2009), Izquierdo-Yusta and Galderon-Monge (2011), and others.
Risk as Mediator	 Pavlou (2003) and others model risk as partially mediating the effects of trust on intention.  Jarvenpaa et al. (2000) incorporate attitude and model a direct effect between risk and intention.
Trust as Mediator	 Dinev and Hart (2006) model trust as partially mediating the effects of risk.  Li et al. (2007) and Chandra et al. (2010) model trust as fully mediating the effects of risk perception.

Figure 3 Trust and Risk in e-service acceptance as modelled in past research (Mou et al., 2017)

In the first configuration perceived risk and trust are stated as independent variables in the prediction of the attitude of users and the behavioural intent to use the e-service. The second configuration expands on the first model of perceived risk and trust as independent variables and adds perceived risk as a mediator between trust and behavioural intent. The third configuration differs from the second in that trust is the mediating variable between perceived risk and behavioural intent.

For this research proposal, risk and trust are stated as independent variables.

2.4.2 Conceptual Framework

Figure 4, below, illustrates the conceptual framework used to test the hypothesis stated.

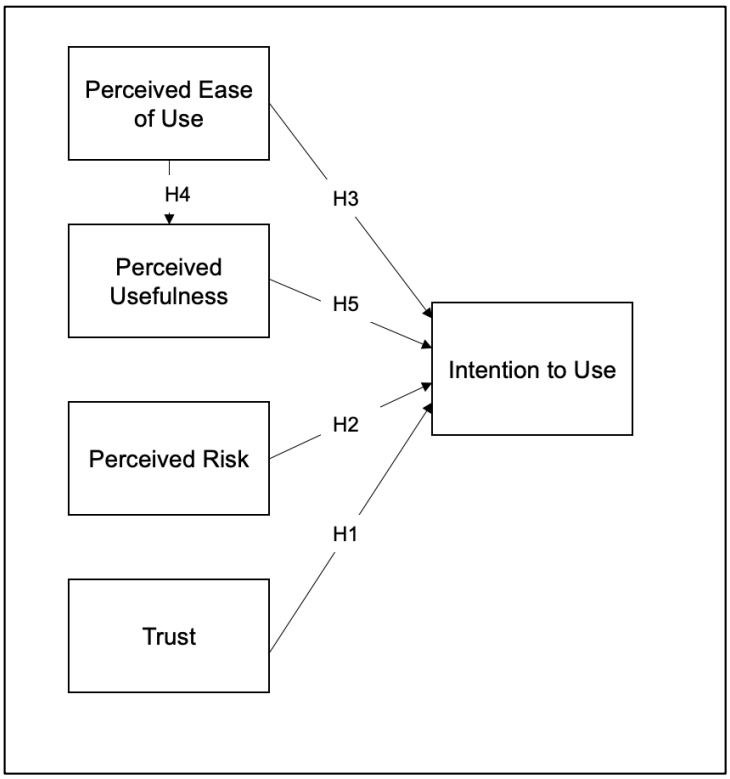


Figure 4 Conceptual Framework and Research Hypothesis to test the Intention to Use ESIM enabled International Roaming

The conceptual framework presents the relevant deductions from the study of the literature review and associated empirical studies. The theoretical framework selected to test ESIM enabled roaming services is TAM with the additional constructs of perceived risk and trust. The framework proposed is based on the empirical study by Pavlov (2003). The study postulates that the factors that drive the adoption of electronic commerce are the constructs of TAM with the additional construct of trust and risk.

The independent variables for the framework are perceived ease of use, perceived usefulness, trust and perceived risks. The dependent variables are the

user intention to use. The intention to use will be an indicator for actual use. The conceptual model represented tests the five research hypotheses H1, H2, H3, H4 and H5.

2.5 Conclusion of Literature Review

This chapter includes the literature review of technology adoption and models used to predict the adoption of electronic services by users. The TAM model with the additional constructs of perceived risk and trust are used to construct the hypothesis for this research study.

H1	Trust is positively related to intention to use ESIM roaming services
H2	Perceived risk is negatively related to intention to use ESIM roaming services
H3	Perceived ease of use is positively related to intention to use ESIM roaming services
H4	Perceived ease of use of the ESIM international roaming service is positively related to perceived usefulness
H5	Perceived usefulness is positively related to use ESIM roaming services

Table 1 Summary of hypotheses to test factors users intention to adopt ESIM enabled international roaming services

3 RESEARCH METHODOLOGY

This chapter outlines the research methodology to test the stated hypothesis and relationships as proposed in the conceptual framework. The methodology explains the quantitative research approach, the research instrument using the Qualtrics tool to enable data collection, the procedure for data collection, the data analysis and validity and reliability of the instrument constructs.

3.1 Research Approach

The research adopted a postpositivist worldview. This perspective supports the use of survey instruments to test models, associated relationships, measure causes and resultant outcomes (Creswell & Creswell, 2018). The research was a non-experimental, cross-sectional study.

The research was approved by the University of Witwatersrand Ethics Committee prior to commencement of the data collection process to ensure that the rights of all respondents were respected during the research process. (Appendix C)

The research approach followed a quantitative methodology using an online survey instrument administered by the Qualtrics tool to collect the primary data. The survey instrument was used to evaluate the intention of mobile South African mobile smartphone users to use ESIM enabled technology for international roaming using the variables of perceived ease of use, usefulness, trust, and risk. The primary data collected from the survey responses was assessed using the SAS online tool. The variables (factors and items) were test for validity using Confirmatory Factor Analysis (CFA). The stated hypotheses were evaluated with respect to the relationships between the construct of perceived ease of use, perceived usefulness, perceived risk, and trust on the resultant outcome of intention to use using Structural Equation Modelling (SEM).

3.2 Research Design

The research question intended to determine the factors that influence the intention of users to use the ESIM technology for international roaming. The research questions and hypotheses related to trust, risk, perceived usefulness and ease of use as the independent variables in the study. The dependant variable was the intention to use international roaming. The research was designed to identify the correlation and hence strength of the relationship between the variables. This quantitative research used the theory of the Technology Adoption Model (TAM) as the theoretical mode for the basis of the research instrument.

The survey instrument was developed using the online Qualtrics tool (Appendix B). The online survey method has the advantages of accessing many mobile users, in a pre-defined period through virtual communication channels. The Qualtrics survey provides anonymity to the respondents. The method is efficient with respect to cost and time for the researcher (Wright, 2017).

A disadvantage of the online survey method is that the response rates remain low for online surveys and due to the anonymity of the recipients of the request, there is no opportunity to prompt participation (Wright, 2017).

3.3 Data Collection Methods

The survey was launched on the 19 February 2023 and closed on the 19 March 2023. The Qualtrics tool collated and organised the survey data as response were received. The data was exported into Excel (text and numerical) in readiness for statistical analysis.

The survey was cross-sectional. All responses were captured as a once off data point.

3.4 Population and Sample

3.4.1 Population

The population under study for this research was the general South African mobile, smartphone users.

3.4.2 Sample and Sampling Method

The non-probability, convenience sampling technique was implemented to the users surveyed. This technique is also referred to as the accidental or haphazard technique. Convenience sampling techniques is preferred when results are expected in limited time frames and with limited resources (a single researcher). The disadvantage of this method is that there is a potential for bias in the surveyed respondents (Etikan, Musa, & Alkassim, 2016). The online survey method administered through unsolicited e-mail and social media platforms too enable ease of access to the large sample size. The risk in this method is that there is no method to check if multiple responses are received from a single participant.

3.5 The Research Instrument

The survey is detailed in Appendix A. The instrument collected 2 distinct data elements.

3.5.1 The Demographics (Section A)

The intent of this section was to determine the demographics of the respondents with respect to age, level of education and annual household income.

The respondents were also requested to provide information with respect to previous roaming experience and the number of times previously roamed using existing technology.

Responses were structured in a nominal scale with mandatory responses for each of the questions.

The descriptive statistics of the demographics is detailed in Appendix D.

3.5.2 Attitudes and Intention to Use (Section B)

This intent of this section was to determine the perceived ease of use and usefulness (the factors of TAM) and the additional factors of trust and risk when using international roaming using ESIM technology. Responses were structured using an ordinal scale. A seven-point Likert scale was used to measure the responses of the items ranging from strongly disagree to strongly agree.

All responses were mandatory.

Table 2 describes the factors (latent variables), the definitions and linked to the references reviewed in the literature reviewed and outlined in the conceptual framework.

Factors	Variable	Items	Definition	Reference
Perceived Usefulness	PU	5	Perception of usefulness of international roaming services enabled by ESIM	(Gao, Krogstie, & Siau, 2011) (Davis, 1989)
Perceived Ease of Use	**PEOU**	4	Perception of how easy it will be to used international roaming services enabled by ESIIM	(Gao et al., 2011) (Davis, 1989)
Trust	**TU**	4	Degree of certainty that ESIM international roaming providers will deliver the service as contracted	(Paul, 2003)
Perceived Risk	**PR**	4	Perception of users that the ESIM service provides will ensure privacy, security, and confidentiality of their personal information	(Paul, 2003) (Taherdoost, 2017)
Intention to Use	**BI**	2	If the context (availability of services and availability of devices) to use ESIM enabled roaming services arises, the user will use the service	(Paul, 2003) (Davis, 1989) (Gao et al., 2011)

Table 2 Research Instrument with Latent Variables

Table 3 describes the items (manifest variables) and labels used in the survey instrument.

Factors	Variable	Item Label	Item Name
Perceived Usefulness	PU	PU1	Access to service
		PU2	Selection of network
		PU3	Use on Multiple Devices
		PU4	Spend monitoring
		PU5	Usefulness compared to existing service
Perceived Ease of Use	PEOU	PEOU1	Ease of understanding
		PEOU2	Ease of provisioning
		PEOU3	Ease of access using digital channels
		PEOU4	Ease of use
Trust	TU	TU1	Trust in provider
		TU2	Trust in digital access
		TU3	Trustworthiness to provide the service
		TU4	Trust to correctly manage charges
Perceived Risk	PR	PR1	Risk to privacy
		PR2	Risk to information security
		PR3	Risk to confidentiality
		PR4	Overall risk of service
Intention to Use	BI	BI1	Intent to use based on availability of service
		BI2	Intent to use based on device availability

Table 3 Relationship between Latent and manifest Variables

The survey provided additional information on ESIM technology to the respondents through two YouTube videos to provide an overview of the ESIM international roaming implementation. The first video provided by Dent Wireless (duration of forty six seconds) provides a summary of ESIM roaming services (Wireless, 2021). The second video content was created by Truphone (duration of three minutes and thirty seven seconds) provides an overview of the ESIM technology and enabling capabilities (Truphone, 2020).

3.6 Procedure for Data Collection

The survey was self-administered and presented through electronic mail and posted on social media platforms (LinkedIn and Facebook) to respondents.

The survey was presented to around 500 mobile users using electronic mail, instant messaging application and on social media platforms (using the in-platform messaging tools). The sample size collected was 165 responses. 23 responses were incomplete.

The demographic profile of the respondents is detailed in Appendix D. 64% of the respondents have used international roaming services previously and 60% of this number have used the services more than twice. Majority of the respondents (60%) are in the age group 26-49 years old and 89% of the respondents have a higher education degree (diploma or higher).

3.7 Data Analysis Strategies and Interpretation

Data collected was exported from Qualtrics to Excel in both numerical and text format. The text data was replaced with the numerical fields for all responses to facilitate the data analysis. The amended excel spreadsheet was imported into SAS OnDemand for Academics tool. The data was screened with the intent to improve quality of the records for statistical analysis. The data was tested for univariate and multivariate outliers. The data was assessed for consistency and reliability of the factors using Cronbach's alpha >0.7.

Confirmatory factor analysis (CFA) was executed between the factors and items to test validity (Whitley Jr & Kite, 2012).

The conceptual model was tested using structural equation modelling (SEM) to test the consistency of the responses received in relation to the model. Path analysis was performed to determine the relationships (direct and mediations) stated in the hypothesis testing (H1, H2, H3, H4, H5).

3.8 Possible Limitations and Challenges of the Study

The possible limitations and challenges identified are of the study.

I. The sampling method selected is convenience. This method has a potential for a selection bias as participants in the survey reflect the profile of persons who are currently employed in professional careers. The sample of the population surveyed are from an MNO or are members of professional social media LinkedIn platform and social media communities associated to the researcher.
II. Response to the survey were requested through email. Response rates observed for surveys administered is generally low (Whitley Jr & Kite, 2012).
III. The study is focused on a limited selection of factors that affect the willingness to adopt international roaming services. The availability of ESIM enabled devices and actual will provide further relevant additional factors.
IV. The study is a cross-sectional survey and will test intention to use without actual use of the technology. A longitudinal study may provide a more robust test of the conceptual model presented.

3.9 Quality Assurance

3.9.1 External Validity

External validity refers to the extent of which the conclusions made in a study can be extended to different samples or the larger population. The concept of external validity in this research must considered jointly with generalisability and transportability. Generalisability refers to conclusions made in a defined sample from the population. Transportability refers conclusions made in a defined sample to a different population (Findley, Kikuta, & Denly, 2021).

The sample method used was a non-probability, convenience sampling technique of South Africans smartphone users. The scope of the research was the perception and intention of mobile users to use ESIM technology for

international roaming, when available. The conclusions and inferences may be generalisable. ESIM technology is inherent to new models of smartphones and other devices across all manufactures (GSMA, 2021b). As availability increases, the inferences from this research may be extended to other ESIM services.

The transportability of inferences and conclusions from this research may be low as the perceptions of users may defer across geographical regions based on their existing international roaming services offerings from their MNO and their cultural perceptions of trust and risk.

3.9.2 Internal Validity

The survey instrument (Appendix A) was derived from two existing studies on the by Pavlov (2003) and Gao et al., (2011). The instrument for this study uses existing instruments as these instruments aligned the theoretical framework, the constructs and the research conditions (electronic services and mobile services) (Cahit, 2015).

Pavlov (2003) in his study looks to predict the adoption of electronic commerce using TAM with the additional constructs of risk and trust. The survey instrument was tested in a controlled sample and revised for the final study to validate the hypotheses.

Gao et al. (2011) in his study proposes an instrument to measure the adoption of mobile service. The instrument tests the constructs of TAM, trust, and personal characteristics to predict intention to use mobile services. Both instruments were administered in samples of student populations.

The survey was based on prior instruments as these instruments were previously tested for validity and reliability.

3.9.3 Reliability

The instrument proposed has four independent variables. Each of the factors have four or more items. The items are constructed to drive factor consistency for the factor and hence improve reliability of the survey instrument. The items

are measured using a seven-point Likert scale. Correlation across the items for the factors were tested using Cronbach Alpha (Whitley Jr & Kite, 2012). The Cronbach Alpha test greater than 0.7 is considered a good test for internal consistency (Taherdoost, 2016).

The survey instrument was further reviewed by persons with knowledge on ESIM products and services, ESIM technical implementation and international roaming services. The survey was updated with the outcomes of their reviews.

3.10 Ethical Considerations

The survey instrument collected primary data. All respondents were informed in the introductory paragraph that their participant was voluntary and informed consent was requested prior to the survey launch. Only demographic data relevant to the study was requested.

The data collected was securely stored in cloud servers accessible only to the researcher.

The survey was designed to be completed in ten minutes and was not intended to inconvenience the participants if they consented to the survey.

The survey was submitted to the Wits Ethics Committee for ethical clearance prior to the commencement of the study.

4 RESULTS

The results presented is the outcome of the analysis of the model developed in the Literature Review and Theoretical Framework sections and the stated hypotheses and tested as per the methodology stated in the Research Methodology. The methodology was a quantitative study involving a multi-item scale measurements in a complex research design. This study deployed correlation-based measures including the correlation analysis of bivariate correlations, analysis of the reliability of the multi-items' scales using Cronbach Alpha, confirmatory factor analysis to test the structure and finally structured equation modelling to test the relationships in the main model.

Section 4.1 presents the correlation matrix with the descriptive statistics, bivariate correlation values and the p-values for the correlations. Section 4.2 presents the Cronbach Alpha detailing the reliability of the factors. Section 4.3 presents the CFA and finally Section 4.4 presents the structural equation model.

4.1 Correlation Matrix

Table 4 reflects the descriptive statistics, bivariate correlation values and the p-values for the correlations.

	Correlations and p-Values								
	Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.	UsedRoaming									
2.	Age	.26***								
3.	Education Level	.31***	.04							
4.	Income	.21*	.12	.25***						
5.	Frequency	-.55***	.05	-.05	-.02					
6.	Perceived Usefulness	.18**	-.05	-.01	-.08	-.10				
7.	Perceived Ease of Use	.11	-.07	.01	-.19**	-.08	.65***			
8.	Trust	.17*	-.02	.03	-.12	-.17*	.61***	.87***		
9.	Perceived Risk	.20**	.02	.12	-.12	-.16*	.46***	.41***	.49***	
10.	Intention to Use	.22***	-.11	.04	-.14*	-.15*	.69***	.78***	.75***	.54***

* $p < .10$
** $p < .05$
*** $p < .001$

Table 4 Correlation Matrix

The analysis in Table 4 reveals a hugely significant statistical relationship between trust and perceived ease of use (r=.87, p<.01).

A large significant, positive statistical relation exists for perceived ease of use and intention to use (r=.78, p<.01). This provides support to the H3 hypothesis indicating that the respondent's intention to use the roaming service is associated with ease of use of the service. A large significant, positive relationship exists for trust and intention to use (r=.75, p<.01). This supports the hypothesis respondents that trust is associated with an intention to use international roaming services. A large, positive statistically significant relationship exists for perceived usefulness and intention to use (r=.69, p<.01). Perceived usefulness is hence associated with the high intention to use this service. There exists a large, positive statistically significant relationship exists for perceived usefulness and perceived ease of use (r=.65, p<.01), supporting the hypothesis, and the TAM model with respect to a mediating effect of perceived ease of use on perceived usefulness. There exists a large, positive statistically significant relationship exists for perceived usefulness and trust (r=.61, p<.01).

A statistically significant, large relation is observed for perceived risk and intention to use (r=.54, p<.01). A statistically significant, positive but moderate relationship is observed for perceived risk and perceived usefulness (r=.46, p<.01), perceived risk and perceived ease of use (r=.41, p<.01) and perceived risk and trust (r=.49, p<.01).

4.2 Reliability

4.2.1 Cronbach Alpha Coefficient

The Cronbach Alpha coefficient (α) was used as a test for the survey instrument for the 142 completed responses received. Cronbach's alpha ranges from 0 to 1.0 to .7 is usually used as the standard for Cronbach's alpha (Bland & Altman, 1997). The items are sufficiently consistent at this level and above to suggest the measure is reliable. Values around 0.7 are typically minimally acceptable.

4.2.2 Summary of Cronbach Alpha

Latent Variable	Cronbach Alpha
Perceived Usefulness	.91
Perceived Ease of Use	.87
Trust	.80
Perceived Risk	.96
Intention to Use	.94

Table 5 Summary of Cronbach Alpha

All Cronbach Alpha coefficients are sufficiently high (> .7). It is concluded that the variables were reliable.

4.3 Confirmatory Factor Analysis (CFA)

CFA was applied to determine whether the hypotheses factor's structure underlying the survey variables were supported.

The assumptions underlying SEM were tested. The assumptions were met with the exception that some of the manifest variables displayed non-normality which were managed by standard linear power transformations.

A complete list of the variables, the mean, standard deviations, kurtosis, and skewness is detailed in Appendix F. All final variables were in the acceptable ranges for kurtosis (range − 10 to + 10) and skewness (− 3 and + 3) for SEM analysis (Edwards, 2010).

Table 6 below reflects the CFA FIT summary reflecting indices values within acceptable guidelines.

	Fit Summary		Guidelines for Acceptable Fit
Absolute Index	Chi-Square	286.44 (Chi-Square DF = 169***)	Significant chi-squared if sample reasonably large (Note 1)
	Standardized RMR (SRMR)	.06	SMSR < .08
Parsimony Index	RMSEA Estimate	.08	RMSEA < .08 Especially if upper end of CI < .10
	RMSEA Lower 90% Confidence Limit	.06	
	RMSEA Upper 90% Confidence Limit	.09	
Incremental Index	Bentler Comparative Fit Index	0.95	CFI > .90
	Bentler-Bonett Non-normed Index	0.94	NNFI > .9

* p < .10
** p < .05
*** p < .001

Note 1: Chi-squared values are dependent on sample size and with a small sample size a significant chi-squared is considered acceptable. (Stone, 2021)

Table 6 CFA FIT Summary

The path list (Table 7) indicates the strength of the relationship between the latent variables and their associated manifest variables.

The following manifest variables have a huge significantly statistical impact on perceived usefulness:

- ease of access to the service (β =.84, p<0.001)
- selection of the network at a foreign destination (β =.85, p<0.001)
- the use of international roaming on multiple devices (β =.80, p<0.001)
- monitoring of spend (β =.86, p<0.001)

It is noted that the usefulness of ESIM roaming (β =.71, p<0.001) has a large, significant relationship with perceived usefulness.

All manifest variables associated to perceived ease of use have a large, significant association.

- Ease of understanding (β =.85, p<0.001)
- Ease to provision and activate (β =.87, p<0.001)
- Ease of use (β =.82, p<0.001)

The trust in digital channel to access the service variables has a huge significant association with the trust variable (β =.83, p<0.001). The other factors of trustworthiness to provide the service (β =.78, p<0.001) and trust in the provide (β =.77, p<0.001) has a large significant association with trust

The manifest variables for perceived risk all have a huge significantly statistical impact on the factors.

- Risk to privacy of the respondent's data (β =.83, p<0.001)
- Risk to information security (β =.94, p<0.001)
- Risk to confidentiality (β =.95 p<0.001)
- Overall risk to the service (β =.87, p<0.001)

It can hence be deduced that a high correlation exists between the measured variables.

Latent Variable		Manifest Variable	Relationship
Perceived Usefulness	==>	Access to service	.84***
	==>	Selection of network	.85***
	==>	Use on Multiple Devices	.80***
	==>	Spend monitoring	.86***
	==>	Usefulness compared to existing service	.71***
Perceived Ease of Use	==>	Ease of understanding	.85***
	==>	Ease of provisioning	.87***
	==>	Ease of use	.82***
Trust	==>	Trust in digital access	.83***
	==>	Trustworthiness to provide the service	.78***
	==>	Trust in provider and trust in the provider to correctly manage charges	.77***
Perceived Risk	==>	Risk to privacy	.83**
	==>	Risk to information security	.94***
	==>	Risk to confidentiality	.95***
	==>	Overall risk of service	.87***
Intention to Use	==>	Intent to use based on availability of service	.92***
	==>	Intent to use based on device availability	.98***

* $p < .10$
** $p < .05$
***$p<.001$

Table 7 Standardised Paths between Manifest and Latent Variables

4.4 Structural Equation Modelling (SEM)

The initial SEM analysed a full set of relations of demographic factors and other factors as outlined in the conceptual model. The factors modelled were Age, Income, UsedRoaming, Education, Frequency, Perceived Usefulness, Perceived Ease of Use, Trust, Perceived Risk, and Intention to Use. As outlined in the CFA, some of the variables were rescaled to ensure that the co-variances were acceptable with respect to variation and direction between the variables.

All incomplete responses with more than 10 missing variables were then removed from the data set and the full information maximum likelihood (FIML) methodology was applied to extrapolate the missing data element. The number of responses used in the final analysis was 146.

A model was tested with only the main TAM variables and the additional variables of trust and risk. This model has good fit and is reported below (Table 8). Thereafter, a model was fit that included all demographic variables. The inclusion of the demographic variables resulted in poor fit. Education, Income, Frequency and Age had insignificant path relations with the main TAM, trust and risk variables. As a result, these demographic factors were excluded to maintain the integrity of the model fit. The continuous assessment of the model for normalized residuals did not indicate any new logical paths to be added to the model. Hence paths as stated by the SEM remained unchanged. A multi-group analysis on UsedRoaming was attempted. However, the sample size in each group was insufficient and as a result the model fit was poor. Appendix D details the demographic data which does not enter the main modelling any further.

A further test was executed to test the mediating effect of trust on perceived risk. The results of this test indicated a weak insignificant relation. This also resulted in poor fit of the model and this relationship is absent from the final model.

Table 8 below shows the FIT statistics for the model.

Fit Summary			Guidelines for Acceptable Fits
Absolute Index	Chi-Square	214.06 (Chi-Square DF = 112***)	Significant chi-squared if sample reasonably large (Note 1)
	Standardized RMR (SRMR)	.06	SMSR < .08
Parsimony Index	RMSEA Estimate	.08	RMSEA < .08 Especially if upper end of CI < .10
	RMSEA Lower 90% Confidence Limit	.06	
	RMSEA Upper 90% Confidence Limit	.09	
Incremental Index	Bentler Comparative Fit Index	0.95	CFI > .90
	Bentler-Bonett Non-normed Index	0.94	NNFI > .9

* p < .10
** p < .05
*** p < .001
Note 1: Chi-squared values are dependent on sample size and with small sample size a significant chi-squared is considered acceptable. (Stone, 2021)

Table 8 Fit Summary Final Model SEM

The final model from the structural equation model is indicated in Figure 5. It is observed that the perceived ease of use has the strongest total effect on the intention to use (β =.61, p<0.001).

Perceived usefulness is a mediating variable in the relationship between perceived ease of use and intention to use. Hence the total effect is the sum of the direct path perceived ease of use and intention to use (β =.45, p<0.05) and the indirect path from perceived ease of use and perceived usefulness (β =.16, p<0.001).

Perceived risk has a modest, positive, significant effect (β =.18, p<0.001) on intention to use. The effect of trust is trivial and insignificant (β =.16, p = .44) on intention to use.

It can be concluded that the hypotheses, H3 (Perceived Ease of Use is positively related to Intention to Use), H4 (Perceived Usefulness is positively related to Intention to Use), and H5 (Perceived Ease of Use has a positive effect on

Perceived Usefulness) are significantly supported by the model. The hypothesis, H1, trust is positively related to intention to use is non-significant. Finally, the hypothesis, H2, perceived risk is negatively related to intention to use, is not supported by this model.

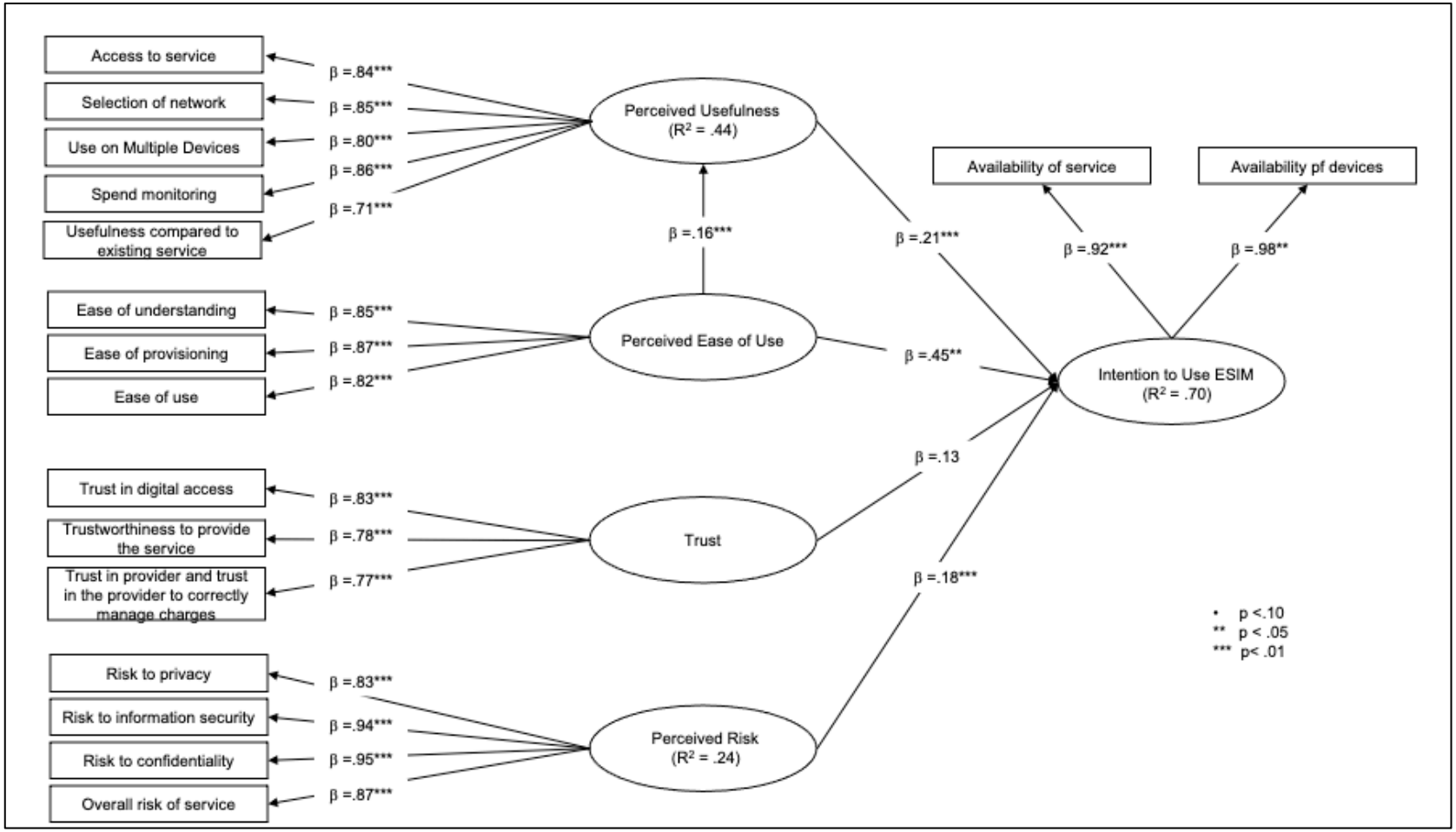


Figure 5 Final Structural Regression Path Model

5 DISCUSSION

International mobile roaming is a service that enables mobile users to use their phones or other mobile devices to browse the internet, send and receive emails, and make and receive voice calls and texts when travelling to another country (GSMA, 2012). Currently, for South African international roamers the service requires users to register with their mobile network operators (MNO) and get roaming authorization before it is made available. Consumers' understanding of the charging structure is not completely transparent. Users receive bills for charges during their monthly billing cycles. The technical (quality of service, network availability, network speeds) and commercial arrangements (price of service) specify and restrict the services offered to visiting mobile customers to those offered by foreign MNOs. For mobile consumers in South Africa, access to international roaming services, service quality, pricing is thus under the control of their local MNO.

The recent development of ESIM technology (Embedded Subscriber Identity Module technology), will actively remove these constraints. The integrated chip set gives devices a higher degree of security (GSMA, 2021a). In the context of international roaming, this technology is significant because it allows ESIM handsets to handle many user profiles (from various MNO) concurrently with the restriction of just one active profile at a time. Users of ESIM mobile devices can authenticate, provision, and switch services across several MNOs without being constrained by physical SIM cards or local MNO. This makes users operator-agnostic since they can access services from numerous networks (GSMA, 2018).

5.1 Discussion of the Results

In this section, the factors that influence the intent to adopt embedded subscriber identity module (ESIM) technology services by South African smartphone users for international roaming are discussed.

Table 9 summarises the results of the stated hypotheses.

Code	Hypothesis	Results
H1	Trust is positively related to intention to use ESIM roaming services	Insignificant
H2	Perceived risk is negatively related to intention to use ESIM roaming services	Significant
H3	Perceived ease of use is positively related to intention to use ESIM roaming services	Significant
H4	Perceived ease of use of the ESIM international roaming service is positively related to perceived usefulness	Significant
H5	Perceived usefulness is positively related to use ESIM roaming services	Significant

Table 9 Summary of Hypothesis Results

H1: Trust is positively related to intention to use ESIM roaming services.

Trust was observed to have a trivial and non-significant effect on intention to use. The implication of this finding is that trust in the provider, trust in the successful delivery of the service and reliability of the service have a weak association to intention to use.

This may be explained by the halo effect. The halo effect is a systemic bias where people transfer an opinion on one product based on previous experiences with similar products (Leuthesser, Kohli, & Harich, 1995). Respondents who have previously used e-services and or international roaming services may not have experience any of the trust factors in the use of the service and hence do not perceive a strong link between trust in an ESIM enable service and intention to use.

This finding is in not completely supported by the literature reviewed. According to Mou et al. (2017), “Trust is important to all forms of social exchange and buyer-seller transactions and reflects a consumer’s belief that favourable conditions exist to facilitate transaction success” (Mou et al., 2017). The study conducted by Pavlou (2003) states that trust positively affects the intention to use e-commerce.

Moreover, a study carried out by Kim, Ferrin & Rao (2008) has observed that trust has a strong positive effect on the intention of purchasing e-commerce services.

H2: Perceived Risk is negatively related to intention to use ESIM roaming services.

According to the analysis, it was observed that the hypothesis is not supported. Perceived risk has a statistically significant effect on intention to use. Perceived risk displays a positive, albeit very low effect (β =.18, $p<0.001$) on intention to use. The analysis indicates that there is a statistically significant spread of respondents who indicated a low level of perceived risk.

This may be due to perceptions among the respondents that the perceived risk is low due to the existing security assurances by providers, remediation processes and legislation (Protections of Personal Information Act in South Africa, General Data Protection Regulation in the European Union, Advancements in Cyber Security protocols and controls) that exist for online services with respect to the inferences of risk relative to privacy, information security and confidentiality. It may be concluded that in the context of perceived usefulness and perceived ease of use, respondents perceive risk to be insignificant to intention to use when they perceive that the provider of service directly addresses the potential risks associated with the mobile services. This aligns with the findings of behavioural intent in e-services pre-adoption studies using TAM (Featherman & Pavlou, 2003).

This result may also be attributed to the premise that responses were based on the prior experiences, in which they had not encountered any harmful acts.

The outcome of this study is contradictory to the literature presented in the literature review. In the study conducted by Mou, et al. (2017) concludes that perceived risk is a contributing factor for the consumer acceptance of e-services. In the context, where, users perceive lower levels of risk, the intention to use in higher. Pavlou,(2003) in the study of e-commerce supports this finding of a strong negative correlation between perceived risk and intention to use. The negative relationship between risk and intention to use is further evidenced by Kim et al.

(2008) who provided evidence that perceived risk reduces a consumer's intention to purchase.

H3: Perceived Ease of Use (PEOU) is positively related to ESIM roaming services.

The outcome of the data analysis indicates a significant association between ease of use of international roaming service for ESIM and intention to use. There is a positive correlation between perceived ease of use and intention to use. The relationship is statistically significant. This factor had the highest positive correlation of all factors modelled (β =.61, $p<0.001$). Respondents perceive the activation, provisioning and use through digital channels to be easier than the existing processes to activate and use international roaming services and hence this result toward intention to use. This finding is supported by the findings by Pavlou (2003) in a study on the consumer acceptance of electronic commerce. It can be concluded that the respondents see the perceived ease of use as a determining factor to intention to use.

H4: Perceived ease of use of the ESIM international roaming service is positively related to perceived usefulness.

A statistically significant positive correlation was observed between perceived ease of use and perceived usefulness. The results indicate a that as the service is perceived as easy to use, the usefulness of the service has a positive association with the intention to use this service. It can be concluded that when the engagement with the service is simple, more individuals will use the technology, which increases its usefulness.

This finding is supported by a study conducted by Pavlou (2003), where he observed a positive correlation between perceived ease of use and perceived usefulness. Ease of use has a strong effect on usefulness; hence ease of use can be indirectly having a positive effect on intention to use. The results are coherent with the results obtained by Zarmpou et al. (2012) in their study to assess the users' acceptance of mobile services and the underlying principles of TAM.

H5: Perceived usefulness is positively related to use ESIM roaming services.

The outcome of the data analysis indicated that respondents perceive that the international roaming service will be useful when it is requested using the ESIM multiple profile functionality. There is a positive correlation between perceived usefulness and intention to use. The relationship is statistically significant. This factor had the second highest positive correlation of all factors modelled (β =.21, $p<0.001$).

The findings reveal that the perceived usefulness of international roaming using ESIM is a factor in the intention to use the service. It can be inferred that respondents may consider ESIM technology for international roaming. It is supported in the study by Pavlou (2003), where it was found that a positive correlation is present between perceived usefulness and intention in the context of e-commerce adoption. Usefulness is identified as a key determinant in the actual use of technology (Adams, Nelson, & Todd, 1992).

5.2 Recommendations

The proliferation of ESIM enabled devices has the potential to disrupt the existing business models of practitioners. This of intent of this research is to explore the most common factors that affect the intention to adopt based on the existing use case for ESIM technology with respect to international roaming. The recommendations are stated separately for practitioners in the mobile services industry and for future research of ESIM enabled services.

5.2.1 Recommendations for Practitioners

ESIM technology in smartphones will result in the independent ownership (network agnostic) of mobile network services subscriptions. Users can change networks without physically changing SIM cards. Currently, the industry has planned for a long phase of parallelism for physical SIM cards and ESIM enabled smartphones. MNO should consider the impact of this attribute of seamlessly switching will impact on user loyalty and network churn.

The proliferation of ESIM devices presents a demand disruption to MNO. Customers now have options to procure international roaming services directly from multiple suppliers without the need for physical SIM cards or future engagement with their MNO. The resultant may be a disintermediation of the existing the international roaming service negotiated between local MNO and foreign MNO and a subsequent elimination of this revenue stream. The recommendation is for MNO to consider active strategies to support ESIM services for international roamers to South Africa and for South African mobile users intending to use ESIM technology while travelling internationally.

As this technology is in the introductory phase in the South African mobile industry life cycle, early adoption may be impacted by the high prices of ESIM enabled smartphones.

As practitioners consider the market engagement model for ESIM, the findings of this study provide an insight into the engagement with users. Accessibility through

digital channels, customer sensing and customer intuitive journeys will drive higher engagements with the service.

5.2.2 Recommendations for Future Research

There is evidence to support the conclusions when the findings of earlier literature were compared with the results of the current investigation, although there were also some discrepancies with respect to trust and risk.

The model has provided an indication of factors that drive the intention to adopt. The relevance of the results can be augmented through the additional factors. The factor of cost of the service and cost of the ESIM enabled equipment will provide more information on the intention to adopt and the factors of perceived usefulness and ease of use.

The sample size can be increased as one method for making the outcome more generalized and improving the external validity. An increased sample size will enable the investigation of intention to adopt based on experienced users and new users. Prior experience in the use of international roaming will influence trust and perceived risk and a further study may reflect trends in the intention to adopt.

To further investigate the impact of trust on the intention to adopt, it is recommended to classifying each construct into several facets (trust can be classified as trust in provider, trust in service platform and trust in technological environment). Currently mobile users in South Africa have a high level of trust in their MNO and this results in higher levels of engagement with their preferred operators (Kruger & Mostert, 2012). This transferring of this trust in mobile operators may be transferred to the ESIM providers. This study does not make this distinction in the measurement model.

It is recommended that the impact of trust and perceived risk be explored more intently. The current study explores trust and risk as independent variables in the model. As per the literature, it will be of interest to model the interdependencies of trust and risk more rigorously and investigate impacts on the intention to adopt

mobile e-services. Future research may explore the relationship between trust, risk, and intention to adopt using other technology acceptance models.

The responses in the survey were based on the introductory video based on an international implementation of ESIM roaming service. Intention to use is determined by a facilitating environment (Venkatesh, Morris, Davis, & Davis, 2003). It is recommended to perform a longitudinal study to determine actual use when ESIM roaming services are launched and more ESIM enabled devices are commercially available.

6 CONCLUSION

The results of the study provide a preliminary insight into the factors that influence the intention to adopt ESIM services for international roaming.

The development of services and new business models enabled through ESIM technology is dependent on the willingness of users to adopt these services.

Perceived ease of use and perceived usefulness were identified as the most significant factors that influence the intention to adopt ESIM roaming services.

Trust defined as the ability of the service provider and enabling technology to provide the service, had a weak influence on the intention to use. Perceived risk too has a low effect on the intention to use.

The findings form a basis for future study of adoption of services in ESIM enabled devices (smartphones, wearables and internet of things devices). Practitioners in the mobile industry may use these findings in the development of services to drive adoption.

APPENDIX A Participant Information Sheet

Dear Participant,

My name is Sharon Singh, a Master of Management in Digital Business student at the Wits Business School registered at the Faculty of Commerce, Law and Management under the supervision of Professor Gregory Lee. To fulfil the requirements of the master's program, I am undertaking a research project to investigate

> **"The willingness to adopt embedded subscriber identity module (ESIM) technology services by South African smartphone users for international roaming ".**

ESIM smartphones have their SIM card embedded into the hardware. This removes the need for physical SIM cards. ESIM smartphones support multiple user profiles (from multiple MNO) simultaneously with the limitation of a single active profile at a time. Please watch the YouTube videos accessible on the links below for more information on ESIM roaming and its current implementation

https://www.youtube.com/watch?v=BLDpmmzgShY

https://www.youtube.com/watch?v=tiEJpP7w9-0

The participation in this survey is limited to mobile users who have travelled internationally and used mobile roaming services (SMS roaming, voice roaming or data roaming services) while travelling. Participation is limited to persons 18 years and older.

Participation in this survey is completely voluntary confidential and anonymous. Some demographic information, such as your age range, educational qualifications and salary scale will be collected, however, no identifying information will be asked – such as names, surnames, or identity numbers.

It will take approximately 15 minutes to complete. Kindly complete all questions in the survey. To access the survey please follow the link below:

Survey link to be Inserted here

If you request any additional information about the study, kindly contact me on the details provided below. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408 or email hrecnonmedical@wits.ac.za.

Looking forward to your participation.

Sharon Singh

2368762@students.wits.ac.za

APPENDIX B Survey Instrument

A confirmation request for voluntary participation will be requested prior to the access to the survey.

Section A Demographic Information

1. Have you used international roaming services in the past?
   - Yes (continue with survey)
   - No (Exit survey)
2. What is your age?
   - 18 – 25 years old
   - 26 – 33 years old
   - 34- 41 years old
   - 42- 49 years old
   - 49 years +
   - Prefer not to say
3. What is the highest degree or level of education you have completed?
   - High School
   - Diploma
   - Bachelor's Degree
   - Master's Degree
   - Ph.D or higher
   - Prefer not to say
4. What is your annual household?
   - Less than R400k
   - R400k – R750k
   - R750k – R 1M
   - More than R1M
   - Prefer not to say
5. How often have you used international roaming services (SMS roaming, voice roaming, data roaming)
   - Once
   - 2 x
   - 3x
   - More than 4 times
   - Never

Section B TAM with Additional Constructs of Risk and Trust

There are no right or wrong answers. Please indicate the extent to which you agree or disagree with the statements below.

Please select only one answer

- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

Perceived Usefulness (PU)

PU1	Using ESIM technology for roaming will improve my access to mobile services when travelling internationally
PU2	ESIM technology will allow me to choose the roaming network at my travel destination
PU3	ESIM technology will encourage me to use roaming services on multiple devices
PU4	ESIM technology will make it easier to monitor my international roaming costs
PU5	ESIM roaming services is more useful than the existing roaming services offered by my mobile operator

Perceived Ease of Use (PEOU)

PEOU1	ESIM roaming services will be clear and easy to understand
PEOU2	I will easily activate and provision ESIM roaming prior to international travel
PEOU3	I will find the digital channel clear and intuitive
PEOU4	I will find ESIM international services easy to use

Trust - I would use the system if

TU1	the provider of ESIM roaming services is widely acknowledged (eg Google, Apple, Microsoft, Current Mobile Operator)
TU2	I feel confident I would successfully activate the international roaming service using digital channels exclusively
TU3	I feel confident that the international roaming service is reliable
TU4	I feel confident that the international roaming charges are accurate

Perceived Risk

PR1	I will use ESIM services if the provider ensures the privacy of its users (privacy protects rights of the individual on how the data is collected, maintained, and shared)
PR2	I will use ESIM services if the provider ensures information security (Technical safeguard of data)
PR3	I will use ESIM services if the provider ensures confidentiality. (Protects against unauthorized use of data)
PR4	I will use ESIM services if the services are safe to use

Intention to Use

BI1	Assuming ESIM service are available to South African mobile users, I intend to use ESIM enabled international roaming
BI2	If my smartphone has ESIM technology, I intend to use ESIM enabled international roaming

APPENDIX C Ethical Clearance Certificate

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/DB2368762/450
This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below

This certificate is only valid if accompanied by formal permission from the relevant stakeholder(s).

Project title	Adoption of embedded subscriber identity module (ESIM) technology by South African smartphone users for international roaming
Investigator / Researcher	Mrs Sharon Singh
Nature of Project	MM (Digital Business)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed anonymity and confidentiality.
Issue Date of Certificate	2023-02-16
Expiry date	Date of submission of the project / research report
Chairperson	Dr Pius Oba ☎ +27 11 717 3976 +27 82 733 6587 pius.oba@wits.ac.za

Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature

19/2/2023
Date:

APPENDIX D Summary of Demographic Data

1. UsedRoaming

UsedRoaming	Frequency	Percent
No	53	36.3
Yes	93	63.7

Table 10 Roaming Experience

2. Age

Age	Frequency	Percent
18 – 25 years old	9	6.16
26 – 33 years old	20	13.7
34- 41 years old	27	18.49
42- 49 years old	40	27.4
49 years +	46	31.51
Prefer not to say	4	2.74

Table 11 Age

3. Education Level

Educational	Frequency	Percent
High School	14	9.59
Diploma	32	21.92
Bachelor's Degree	69	47.26
Master's Degree	26	17.81
Ph.D or higher	3	2.05
Prefer not to say	2	1.37

Table 12 Education Level

4. Income

Income	Frequency	Percent
Less than R400k	18	12.33
R400k – R750k	21	14.38
R750k – R 1M	18	12.33
More than R1M	59	40.41
Prefer not to say	30	20.55

Table 13 Income

5. Frequency of Use

Frequency	Frequency	Percent
Once	11	7.53
2 x	17	11.64
3x	10	6.85
More than 4 times	61	41.78
Never	47	32.19

Table 14 Frequency of Use

APPENDIX E Cronbach Coefficient per Latent Variable

Perceived Usefulness

The perceived usefulness factor comprised 5 items. The Cronbach Alpha is .91 indicating a strong correlation between the manifest variables for this variable.

Variable	Manifest Variable	Mean	Std Dev
PU1	Access to service	5.53	1.64
PU2	Selection of network	5.59	1.53
PU3	Use on Multiple Devices	5.35	1.61
PU4	Spend monitoring	5.26	1.63
PU5	Usefulness compared to existing service	5.20	1.47

Table 15 Cronbach Alpha - Perceived Usefulness

Perceived Ease of Use

The perceived ease of use comprised 4 items. The Cronbach Alpha is .87 indicating a strong correlation between the manifest variables for this variable.

Variable	Manifest Variable	Mean	Std Dev
PEOU1	Ease of understanding	5.19	1.34
PEOU2	Ease of provisioning	5.49	1.24
PEOU3	Access using digital channels	5.21	1.21
PEOU4	Ease of use	5.32	1.20

Table 16 Cronbach Alpha Perceived Ease of Use

Trust

Trust comprised 4 items. The Cronbach Alpha is .8 indicating a strong correlation between the manifest variables for this variable.

Variable	Manifest Variable	Mean	Std Dev
TU1	Trust in provider	5.87	1.18
TU2	Trust in digital access	5.51	1.23
TU3	Trustworthiness to provide the service	5.21	1.21
TU4	Trust to correctly manage charges	4.87	1.39

Table 17 Cronbach Alpha Trust

Perceived Risk

Perceived risk comprised 4 items. The Cronbach Alpha is .96 indicating a strong correlation between the manifest variables for this variable.

Variable	Manifest Variable	Mean	Std Dev
PR1	Risk to privacy	5.94	1.15
PR2	Risk to information security	6.15	1.11
PR3	Risk to confidentiality	6.21	1.07
PR4	Overall risk of service	6.24	0.94

Table 18 Cronbach Alpha Perceived Risk

Intention to Use

Intention to use comprised 2 items. The Cronbach Alpha is .94.

Variable	Manifest Variable	Mean	Std Dev
BI1	Intent to use based on availability of service	5.80	1.28
BI2	Intent to use based on device availability	5.77	1.32

Table 19 Cronbach Alpha Intent to Use

APPENDIX F Descriptive Statistics – Mean and Covariance for All Variables

Variables	Mean	Std Dev	Skewness	Kurtosis
UsedRoaming	1.63380	0.48176	-0.55547	-1.69145
Age	3.74648	1.25842	-0.57479	-0.55766
Educational	2.83803	0.99036	0.19777	0.56257
Income	3.45775	1.27060	-0.63660	-0.71931
Frequency	3.78873	1.23808	-0.95259	-0.16912
Access to service	5.57746	1.58035	-1.35196	1.19863
Selection of network	5.61268	1.51448	-1.45622	1.76255
Use on Multiple Devices	5.31690	1.58944	-1.06380	0.41644
Spend monitoring	5.26761	1.62687	-1.04419	0.32478
Usefulness compared to existing service	5.20423	1.44641	-0.77781	0.20095
Ease of understanding	5.20423	1.35074	-0.87139	0.76790
Ease of provisioning	5.49296	1.26015	-0.96597	1.21159
Ease of use	5.33803	1.20379	-0.79188	0.68990
Trust in digital access	5.54225	1.21391	-1.22058	2.02705
Trustworthiness to provide the service	5.21831	1.21676	-0.82159	0.75287
Trust in provider and trust in the provider to correctly manage charges	2.43143	1.03861	-0.40038	-0.77088
Risk to privacy	2.66138	0.99243	-0.76945	-0.10698
Risk to information security	2.71757	0.97421	-0.81570	-0.03745
Risk to confidentiality	2.71075	0.91501	-0.65741	-0.20239
Overall risk of service	5.79577	1.27566	-1.38483	1.85450
Intent to use based on availability of service	5.77465	1.31296	-1.52112	2.34705
Intent to use based on device availability	3.62476	0.95481	-0.55201	-0.11631

Table 20 Mean and Covariances

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