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Understanding and Predicting the Determinants of Consumers' Acceptance and Usage of M-commerce Application: Hybrid SEM and Neural Network Approach

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Abstract

In m-commerce, privacy and security are major concerns. Existing research has examined the privacy and relationship, security, and intention to use. However, the determinants of privacy and security in mobile commerce remain largely unexplored. A study based on UTAUT2 and trust examines the factors that influence mobile commerce privacy and security. By using the approach of hybrid SEM/ANN analysis, it is possible to detect non-linear and non-compensatory relationships. According to linear and compensatory models, the absence of one determinant can be compensated for by another. The decision-making process of consumers is actually quite complex, and non-compensatory or linear models tend to simplify it. The sample is collected by using a mobile commerce application in order to gather 890 datasets on mobile commerce consumers. Findings: (1) Two determinants of M-commerce acceptance and use had an explicit and significant positive effect. Security and individual are two of these factors. (2) Privacy concerns have a severe negative impact on M-commerce acceptance and use. (3) Trust is found to partially mediate the effect on behavioral intentions of Security Factors (SCF), Privacy Factors (PRF), and Individual Factors (INF) on m-commerce in Jordan (INTENTION). According to the integrated model, m-commerce offers 71% privacy, security, and trust.

Keywords:
Privacy; Security;
Acceptance;
Mobile Commerce;
Application;
Neural Network Approach.

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1- Introduction

The rapid exchange of information among consumers has changed the e-business environment and enhanced the formation of a social and reliable transaction environment. Moreover, the growth of mobile phone production technology has paved the way for the formation and development of mobile commerce (m-commerce) [1]. Although an increasing number of retailers and wholesalers are flourishing from the growing trend of internet shopping worldwide, the highest rate of online trading through mobile phones is in the Middle East [2]. With the growth of the digital economy, m-commerce has become an essential element in business strategy [3]. According to Chong et al. [4], software companies may decide not to manufacture m-commerce applications due to a lack of users. Similarly, users may be hesitant to

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utilize m-commerce because of its service shortage [5, 6]. In the past few years, there has been a significant increase in research on privacy, security, and trust in e-commerce [7–9]. Such an increase in the literature was due to the sheer volume of user-created content and lack of physical confrontation, unlike conventional trading [10]. In other words, since the authenticity of the content is not verified due to a lack of verbal, non-verbal, and body language expressions, obtaining the trust of m-commerce users is likely to be complicated [11]. Previous studies focused on the importance of privacy, security, and trust in the growth of product loyalty [12, 13], social participation, social shopping, and buying in m-commerce [14]. Literature has concentrated on analyzing customer satisfaction and loyalty using SEM with ANN. Additionally, there is minimal adoption of evaluating privacy, security, and trust in mobile commerce using the UTAUT theory. Moreover, the literature analysis confirmed the modelling and evaluating privacy, security, and trust in mobile commerce need to be investigated.

This study bridges such challenges in the current literature by modelling and evaluating privacy, security, and trust in m-commerce using a linear and non-compensatory approach. M-commerce can be one of the most attractive areas for study because the subject matter is yet to be fully explored and provides possible chances for future study and applications [7, 15]. Therefore, using the structural equation modelling technique and neural networks addresses the shortcomings of previous studies in terms of multivariate assumptions. Besides, exploring linear and non-compensatory relationships may help different m-commerce firms improve the social commerce construct. The concept of mobile wallet adoption has become common in both developed and developing countries to improve the scale, productivity, and superior of banking services [16, 17]. Due to the pro-innovation bias, a focus has been on adopting technology, and little attention has been given to the resistance to innovation, particularly in the m-wallet context [18]. Moreover, the determinants of privacy, security, and trust in m-commerce and the application of the dual theories from SEM and ANN have been rarely investigated [10].

The ANN is a computational structure designed for emulating the accumulation of information in the organic central nervous system [19]. The practice of current ANN mechanisms for analyzing customer attitudes can be helpful for startup firms [19]. The benefits of applying the ANN method with AMOS-SEM techniques are based on enabling further confirmation of the SEM analysis's findings. Additionally, such a method captures linear interactions between antecedents and dependent variables and dynamic, nonlinear interactions and a perfect measure of each predictor's relative strength [19]. This study addresses the existing gap by examining the curbs of m-commerce innovation acceptance and usage through the vision of UTAUT2 and applying a sophisticated hybrid two-stage SEM-ANN approach. To the best knowledge, the research has focused on customer perceptions of security. Therefore, the core contribution pertaining to this research is to understand the customer security perception of mobile commerce applications in Saudi Arabia and provide a model to improve customer security perception, which can be generalized to other geographic regions.

2- Literature Research

2-1- Studies on M-commerce Acceptance and Use

There is a number of studies related to the m-commerce acceptance and use. Tkáč & Verner [19] explore the major factors that affect adopting e-commerce for online shopping to form technical aspects such as payment security and payment data encryption. Further, Ilin et al. [20] investigate the adoption of e-business in enterprise resource planning by identifying the perceived security concern as a factor that affects the adoption within specific organizational and environmental contexts, knowing that the security concern affects directly on the adoption of different systems. Mousa Jaradat & Al Rababaa [21] and Ndayizigamiye & Khoase [22] investigate the security concern from the general concern, which affects the adoption of e-commerce without the consideration of security dimension and measurements that would contribute in understanding the specific security and privacy dimensions.

Alsharif [23] extends the perceived credibility to involve security, trust, privacy, and risks, including the factors pointed out in the findings that have an impact on the adoption of online shopping systems. The investigated factors are analysed from general aspects of perceived credibility. Furthermore, the study lacks the dimensions of security, privacy, and trust. Alsharif [23] investigates how mobile banking adoption might be hindered or facilitated by incorporating three additional constructs which are security, privacy, and trust. They prove that behavioral intentions towards mobile banking services were influenced by general constructs of perceived security, perceived privacy, and trust. Sarkar et al. [1] examine the influence of trust and how the implications of trust can help marketers design more appropriate strategies. The results indicated that perceived security is a sub factor of the risk construct that put impact on trust in m-commerce. Therefore, this study concludes that all trust antecedents of m-commerce represent a significant except for perceived privacy. Rana et al. [24] introduce a framework considering that trust in mobile commerce depends on the way users view security and privacy online. Eneizan et al. [25] developed a model that included trust as a mediating factor based on technology's acceptance and user acceptance. Al-Khalaf & Choe [26] determine that perceived security possesses the strongest correlation with trust, based on technology's acceptance [27] that is focused on understanding mobile commerce's intentions of consumers, and which investigates the trust from the point of distance, communication quality, and mobility. One B2C cross-border platform was considered in the study. Because of this, it is unlikely that the results will generalize to other cross-border e-marketplaces.

Cui et al. [27] examine privacy extensively by proposing a collaborative filtering recommendation method that combines the privacy level of concern and introduces factors that affect privacy's level of concern, including privacy tendency, internal control point, openness, extraversion, agreeableness, and social group influence. Users' acceptance of mobile personalized services is not taken into account by the study since trust and security constructs are not considered in return. Kaatz [28] examines privacy and security constructs as an affecting factor on mobile commerce service quality by extending the results from Cui et al. [27], who conducted a meta-analytic review of electronic service quality. It is proven from the study that privacy and security constructs contribute directly to overall perceptions of mobile service quality.

Ahamad & Pathan [29] provide a technical solution for proximity payments based on the Near Field Communication (NFC) for Secure and Privacy-Preserving Mobile Commerce (SPPMC). In addition to ensuring the privacy of communication, the SPPMC framework ensures the privacy of information. The confidentiality of clients is ensured through the use of Traceable Anonymous Certificates (TACs). The study contributes to the detailed and technical formwork to secure protocols from attacks. As an alternative solution, Ogundoyin [30] proposes an efficient and privacy-preserving protocol based on certificate less public key cryptography, which uses elliptic curve cryptography. Ahamad & Pathan [29] aim to extract barriers to mobile commerce adoption from the literature and form their framework based on the use of the Interpretive Structural Modelling (ISM). Studies have found that security and privacy concerns are strongly affected by the other underlying factors in the ISM model and may be the most significant deterrent to small and medium businesses' adoption of mobile commerce.

The amount of research conducted on M-Commerce acceptance and use is insufficient, particularly in the context of privacy and security concerns. Previous literature has addressed privacy and security issues from a single dimension where detailed analysis is needed to undertake these issues. In general, no existing studies have addressed the multidimensional privacy and security factors in the context of M-Commerce from the consumer's perspective. A few studies looked at trust as a mediator between privacy and security when it came to using mobile commerce. Moreover, most of existing studies applied TAM or UTAUT with privacy and security as single dimension, and hence, there are limited studies that addressed privacy and security as a multi-dimension with the UTAUT in the context of M-commerce in developing countries.

2-2- Developing a Model and Hypotheses for the Research

2-2-1- Representations and Theories of Technology Acceptance

UTAUT2

There is a variety of theories, including theory of planned behavior (TPB), TAM, and UTAUT, which are applied to study M-commerce acceptance and use. By contrast, there are relatively few studies for analysing M-commerce acceptance and use with UTAUT2. Thus, UTAUT2 is used in the present study. Venkatesh et al. [31] modify the UTAUT model to further focus on consumers, leading to UTAUT2. In order to judge a specific technology's acceptability and usage among consumers, UTAUT2 is developed. Age, gender, and experience are the only moderators of UTAUT2-constructs. It's a voluntary use, since the target population is not required to use technology.

Three other concepts are introduced in UTAUUT2: Hedonistic motivation, Price Value, and Habit. The hedonistic motivation and the price value produce behavioral intentions, and habit rationalizes both behavioral intentions and uses. With respect to UTAUT2, extensions generated a significant reduction in the variance explained by behavioral intentions of 56% to 74% and technology used 40% to 52% [31]. However, Raman and Don [32] point out that free systems should not be judged on the basis of price. Due to the fact that m-commerce systems are available for free to consumers, the study excluded the price value.

Various studies show that most consumers use and extend TAM or its extensions to implement consumer health information technology [33-35]. UTAUT and TAM are not designed with the consumer in mind. The UTAUT2 model is developed with this purpose in mind, and it achieves outstanding results [31]. A recent study demonstrated that the UTAUT2 extension is useful for evaluating the critical determinants of EHR adoption [36], but it does not address different privacy and security concerns.

UTAUT2 (Individual Factors)

The UTAUT2 is comprised of five components: performance expectation, effort expectation, social influence, facilitating conditions, conscious motivation, and price value. The study by Rosli et al. [37] considered each variable individually. In the context of mobile commerce, UTAUT2 is applied [38, 39]. In addition to these factors, the present study also examined them individually.

It was suggested in Venkatesh et al. [31] that performance expectancy relates to "the extent that, by using technology, consumers will be able to accomplish certain tasks better." Performance expectancy, therefore, refers to the characteristics of an information system that can benefit its users [13]. Earlier research conducted by Alalwan et al. [40]

has shown that individuals are more likely to adopt and use new technologies if they perceive them to be beneficial [31]. When it comes to m-commerce, performance expectancy involves how much a consumer feels an m-commerce application would benefit the successful completion of their business transactions [41]. A measure of effort expectancy is defined by Venkatesh et al. [31] as the ease of consuming technology. Thus, m-commerce transactions is further comfortable for consumers. Mousa Jaradat & Al Rababaa [21] found that the expectation of effort is positively related to the intention for using m-commerce when examining m-commerce adoption. People perceive social influence as believing others think they should do something new [42]. Whenever they are interacting with other people, they have a desire to be accepted by the group and follow the rules [43, 44]. The popularity of social media has been found to have a significant influence on mobile commerce usage [45]. Individuals may use mobile commerce on their own, but family and friends can influence them to do so as well. Additionally, many people are interested in impressing others by saying they bought something using their smartphone. As a result, we formulate the following hypothesis:

Facilitation refers to the perception that consumers have of available resources in order to perform given behaviors" [31]. Facilitation conditions, are perceived barriers or available resources that make m-commerce more attractive to users. A consumer's access to mobile internet and how much it costs may influence the choice of mobile apps for shopping. Initial, facilitation conditions are only considered as predictors of the UTAUT usage behaviors [31], which are ultimately concluded that the facilitation conditions affect behavioural intention to adopt the technology. Venkatesh et al. [31] "define price value as" the trade-off consumers make between the perceived value of an application and the actual cost of using it." This is especially apparent when it comes to consumer technology. For many consumers, using technology will result in a premium approach. In general, behavioural intentions should be influenced by price value when the perceived advantages of using the technology are higher than the cost to use [31]. The benefit of using mobile applications in the context of m-commerce can be viewed as being greater than the monetary cost of conducting similar transactions face-to-face or in some other ways. A consumer's hedonistic motivation derives from the pleasure derived by utilising a particular technology [31].

As a result, the UTAUT2 hedonic motivation is included so that consumer adoption of technology is not solely dependent on belief systems and usage preferences, since user's attitudes are continually changing nowadays and are concerned with viewing technology from their point of view. Consequently, an individual's ability to derive enjoyment or pleasure from technology use is one of the most important determinants of the consumer's acceptance [31, 46]. It is said that habits are learned behaviours that become automatic responses to cues as they accumulate over time [47]. According to (Liao et al., 2006), habits are added to TAM, finding that people who develop habits with respect to a particular website are more likely to return. The study of Venkatesh et al. [31] indicates that both conscious and unconscious actions affect behavioural intent. Based on what was discussed above:

Hypothesis 1. Individual factors positively effect on intention to use M-commerce.

Internet Privacy Concern (IPC)

Recently, 91% of consumers believe they no longer control their personal data and information [48] and 70% say privacy is a more important concern today than a few years ago [49]. In response to the growing concern about privacy, consumers are changing their behaviour, including closing down their social media accounts and limiting their online shopping [49]. For that reason, online companies must understand what drives and inhibits privacy concerns, so that they can create policies that will assist in alleviating them.

Business ethical research has traditionally focused on different privacy concerns (e.g., [50-53]. An Internet privacy concern (IPC) is a concern that individuals have over the possible loss of privacy when their personal information is voluntarily or surreptitiously disclosed. The conceptualisation of the IPC extends to the online environment the conventional concept of privacy concern, which relates to the perception of fairness in relation to information privacy. As a dyadic relationship, the IPC concept can be viewed as forming between an individual and an online entity. This can either be a particular website or a website in general. There have been similar definitions in prior IPC-related research.

Although many studies have been conducted on IPC, the focus is on the relationship between privacy concerns and outcomes, with little regard devoted to antecedents and privacy concerns [56]. Even though some studies have examined factors to influence a person's awareness of privacy and concern for privacy (e.g. [57, 58]). A number of external, internal, and situational factors can affect IPC, making the identification of critical antecedents impossible. A person's perception of what is fair or unfair can be influenced by the legal and cultural environments [59, 60]. Furthermore, different individuals perceive external factors differently depending on their own personal characteristics [61, 62], and based on their previous experiences [63]. The results of the previous studies have provided some insights into the previously observed relationships between privacy concerns and a variety of antecedents, but were usually conducted in an uncoordinated manner [56].

An ambitious theoretical framework is needed to properly guide identification and examination of the antecedents of the IPC, which is a major research topic in the field of privacy, a comprehensive theoretical framework is needed [49].

There are six key dimensions that are most commonly used in prior conceptualizations of IPC. Awareness, collection, secondary use, errors, unauthorized access, and control are different examples with this regard. In order to make these definitions more relevant to the present research context, we adapted them. Specifically, collection refers to the concern an individual has about the extent to which a website collects individual-specific data [64].

It is also known as a secondary usage in terms of the degree to which an individual is concerned. Additionally, their information is collected for one purpose. Nonetheless, it is later used for another purpose without their permission [65]. This refers to the degree to which people are concerned that websites do not do enough to prevent deliberate and accidental errors in the collection and use of personal data [65]. In general, improper access implies that data is held by a website that can be accessed by people who do not have the appropriate authority to have access through to the data [56]. Concern over control reflects a person's concern over not having adequate control over the information that is kept by particular websites [64]. Furthermore, awareness involves someone's concern about the way in which he(she) knows about the privacy policies of the websites they frequently make use of Malhotra et al. [64].

Hypothesis 2. IPC factors negatively effect on intention to use M-commerce.

Security

M-commerce may be a lucrative business path, but security concerns interfere with its success [66]. Users' perception of security plays an integral role in their decision to use a particular technology [66]. "Any circumstance, condition, or event with the potential to cause economic hardship to data or network resources, from data destruction to disclosure to modification, from denial of service to fraud, waste, and abuse" [67]. In business environments based on information and information systems, security threats are a challenge that all businesses face. Likewise, security threats are critical in e-commerce and mobile commerce environments, where the growth of these technologies is restricted [68]. As data exchanges through an open medium which serves as a communication medium, m-commerce is facing additional threats due to its dependence on wireless computing, which has significant vulnerabilities due to the dependence on open standards [69-72]. The most common security threat in online environments is the user's concern about confidentiality, integrity, and availability of data [73] where these concerns increase with the use of wireless mobile technology.

A lack of standards for the security of online transactions is another major security issue in online environments [68]. E-commerce security is being challenged by malicious code problems that are spread by m-commerce. The increased capabilities of handheld mobile devices that are coupled with wireless connectivity make it likely that malicious code threats will be used against mobile commerce security [69].

Hypothesis 3. Security positively effect on intention to use M-commerce.

Trust as a Mediator

It is believed that customers and web vendors lack trust in each other since the number of online buyers and users has not grown as rapidly as it should [74, 75]. Customers' perceptions of trustworthiness of E-vendors are significant factors in achieving their consent to submit personal information in m-commerce environments [76]. Customer trust in online vendors is divided into two stages: the initial stage and the experience stage [77]. It is common for customers to deal only occasionally with the e-merchant in the initial stages. This depends on several factors such as the company's reputation, the company's guarantee, the website quality, the customer's dispositional trust, and the customer's perception of the situation. Typically, a customer who has done business with the e-vendor previously will put his trust in the e-vendor based on his own assessment of the vendor's capabilities, integrity, and benevolence. According to their research, customers' perceptions of a vendor's benevolence, ability, and integrity affect their perceived trustworthiness [78].

Siau & Shen [79] suggest a number of methods for establishing users' trust in mobile commerce; among these are improving customer familiarity, establishing the reputation of vendors, providing high-quality information, assuring third-party recognition and certification, and offering incentives. Other strategies they suggested for fostering continuous trust development included improving site quality, sharpening business competence, ensuring company integrity, posting privacy policies, strengthening security controls, fostering a virtual community, encouraging communication, and using audits to monitor operations.

Other trust signs in online environments may include use of third-party security seals, privacy policies, third-party security seals, and security standards, where significant correlations are depicted when comparing these indicators to customer perceptions of the trustworthiness of online vendors [80, 81].

Hypothesis 4. Trust positively effect on intention to use M-commerce.

Hypothesis 5. Trust mediates the relationship between security and intention to use M-Commerce.

Hypothesis 6. Trust mediates the relationship between IPC factors and intention to use M-Commerce.

2-3- Extended Model

Along with all the previous variables, the literature shows the relevance of perceived trust and privacy and security, variables included by different authors in similar research using UTAUT/UTAUT2 [82, 83]. The present study was based on previously established theoretical foundations and relevant literature which suggest the importance of privacy and security from multidimensional to more understand of these factors from consumer perspective in context of developing countries such as Jordan. Moreover, few studies addressed trust as mediate between privacy and security with intention to use mobile commerce. This study aims to evaluate an adaptation of the UTAUT2 model to explain the m-commerce behavior (see Figure 1) consumers in Jordan. This adaptation considers the variables of the UTAUT2 model with additional variables perceived trust and perceived security.

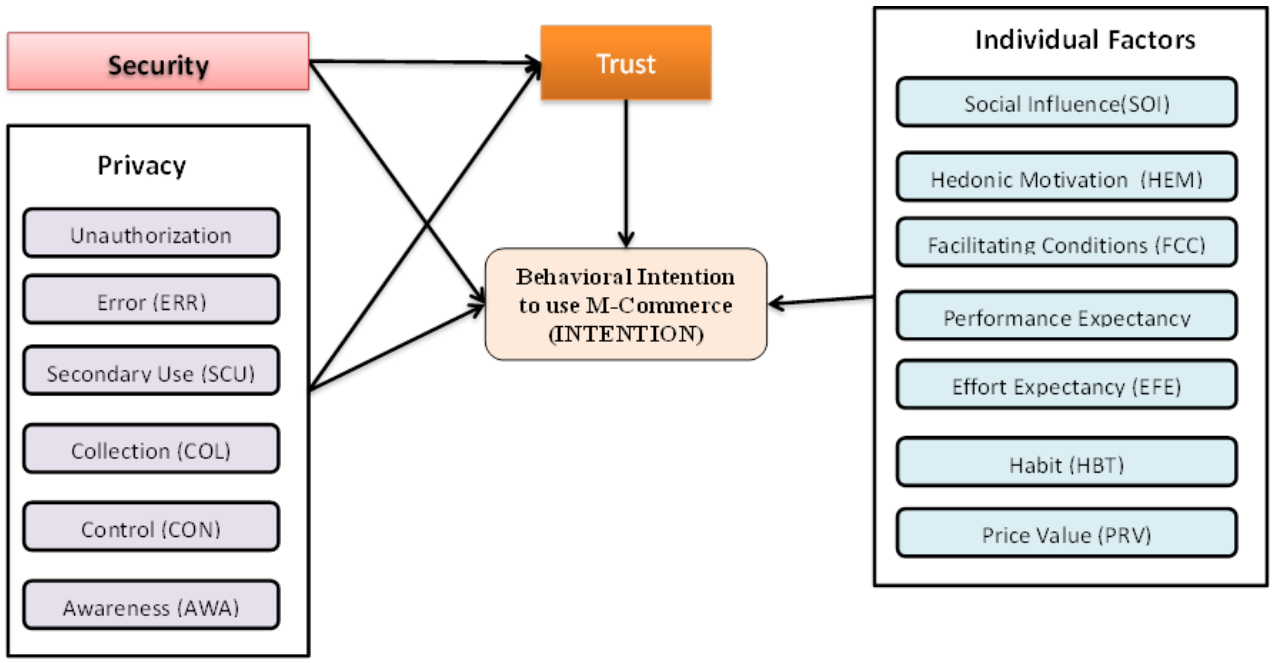

Figure 1. Proposed Framework

3- Research Methodology

3-1- Sample Population and Sampling Results

In Jordan, a self-administered public opinion survey is conducted online between May to July of 2021. The target for the campaign is online consumers. The sampling frame is using the random sampling method. A total of 931 valid responses were collected. The process of cleaning and examination is conducted to avoid missing values, abnormally high or low values, and normal variances. The deletion of 43 cases also included those with incomplete information, missing data, and outliers. At the end, 890 cases of the usable responses are retained for statistical analysis.

3-2- The Instrument

Respondents fill out a questionnaire by using a 5-point Likert scale. Among the five levels of response, there are (1) strongly disagrees and (5) strongly agrees. Based on the Cronbach's Alpha value in Table 1, the reliability of the pilot study is evaluated.

Table 1. Instrument

Variables	Items	Cronbach's Alpha
Intention to use M-commerce	4	0.735
Security	4	0.777
IPC	24	0.869
Individual	30	0.864
Trust	4	0.751

3-3- Data Collection

Data collection is completed from May to July of 2021. Online questionnaires are approximately distributed among the participants of the survey. The researcher use 890 questionnaires, which are fully completed and considered for further analysis

Linear Structural Equation Modeling (SEM): FA is the first stage of SEM

Researchers analyse the measurement model by using the CFA. Each latent construct is associated with a corresponding indicator within the overall measurement model. The CFA model is shown in Figure 2.

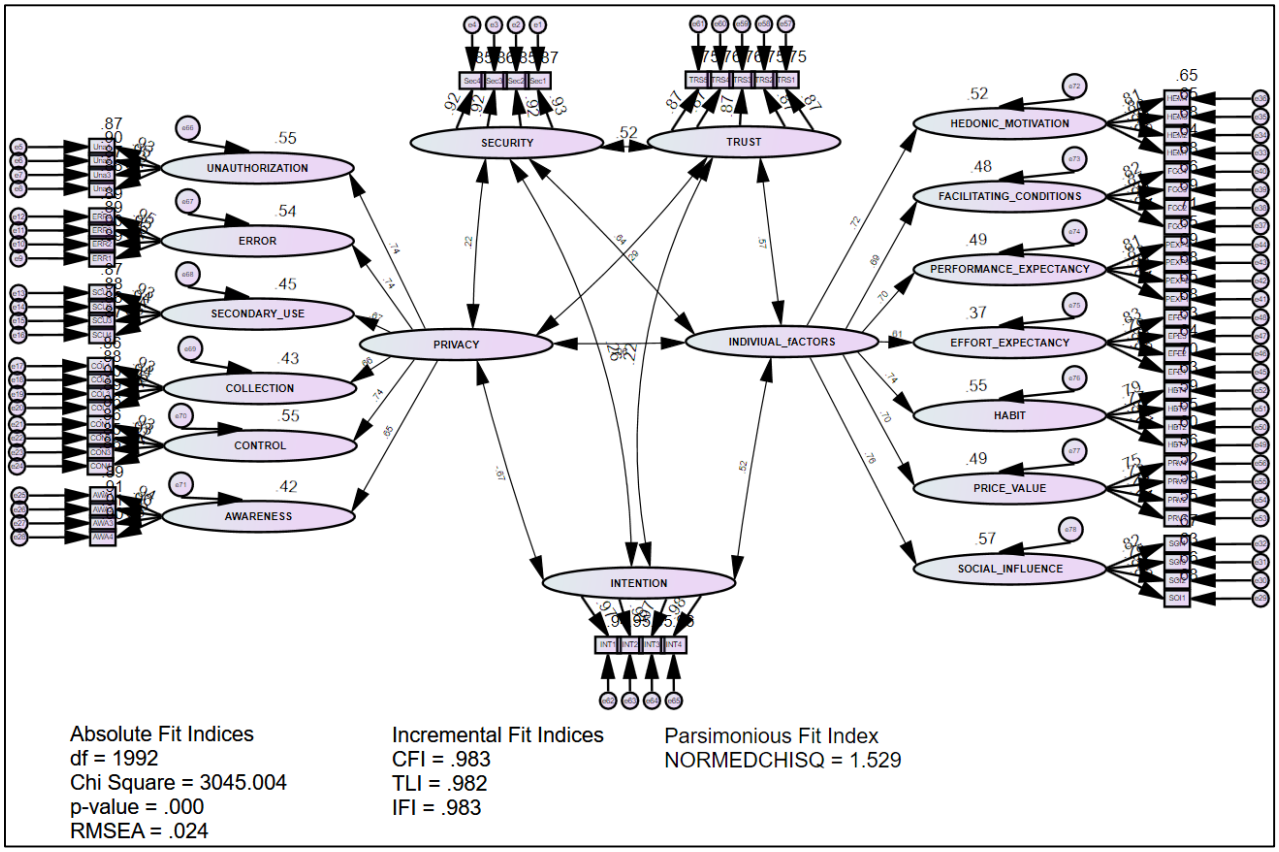

Figure 2. The CFA Model

3-4- Goodness of Fit Indices

Goodness of fit tests are used in the overall model, and all measurements use an adequate fit of data. Additionally, Table 2 contains Convergent & Discriminate validity and Reliability and all obtained results. These results are including AVE > ASV & MSV, AVE >0.50, CR > 0.7.

Table 2. Convergent & Discriminate Validity

	CR	AVE	MSV	Max R(H)	Security	Trust	Intention	Privacy	Indiviual_Factors
Security	0.960	0.858	0.416	0.960	**0.926**				
Trust	0.939	0.755	0.326	0.939	0.525***	**0.869**			
Intention	0.986	0.947	0.444	0.986	0.258***	0.220***	**0.973**		
IPC	0.851	0.489	0.444	0.855	0.215***	0.293***	-0.666***	**0.699**	
Indiviual_Factors	0.872	0.495	0.416	0.876	0.645***	0.571***	0.520***	-0.062	**0.704**

Stage 2 of SEM: Structural Model

An examination of the statistical study model is conducted to determine how independently variable (security, privacy, and individual factors) affects the dependent variable (intention to use M-commerce), and how they compare to the first, second, third, and fourth hypothesis (see Figure 3).

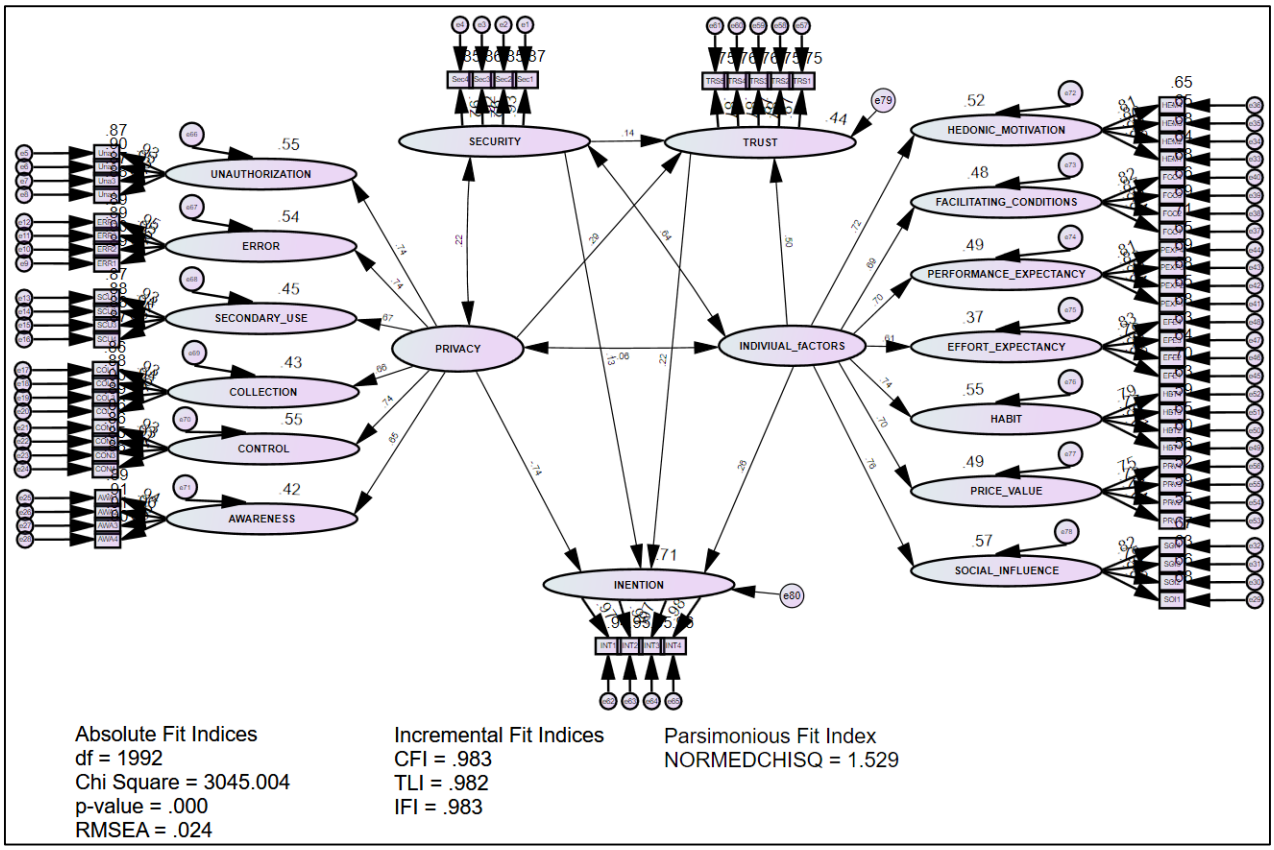

Figure 3. The Structural Model

Using AMOS 26 for hypothesised effects testing, Figure 3 represents the standardised regression weights. It is clear from the GOF indices that the structural model is a good fit for the data: MIN= 2113.256, DF 1605.000, CMIN/DF =1.317, CFI = 0.991, SRMR= 0.019, RMSEA= 0.019 PCLOSE = 1.000.

Effects that Occur Directly and Indirectly

Table 3 presents the path coefficients and direct effects hypothesized. A p-value that is greater than 0.05 is required for all hypotheses to be accepted. As shown in Table 4, TRUST mediates the effects of (security and privacy) on intention to use M-commerce. Therefore, H5 and H6 are supported where an illustration of indirect and direct effects are shown in Tables 3 and 4.

Table 3. Coefficients and direct effects hypothesized

Hypothesis				Estimate	S.E.	C.R.	P- value	Hypotheses result
H1	INDIVIUAL_FACTORS	→	INENTION	0.264	0.08	6.239	***	√
H2	IPC	→	INENTION	-0.742	0.04	-19.049	***	√
H3	SECURITY	→	INENTION	0.134	0.039	3.96	***	√
H4	TRUST	→	INENTION	0.215	0.038	6.585	***	√

Table 4. Mediation effects of TRUST via bootstrapping: Indirect Effect

DV = INTENTION - M = TRUST	Independent Variables (IVs)	
	Security (SC)	IPC
The total effect IV of DV without M (path a)	0.165	-0.679
DV with IV versus M (path a')	0.134	-0.742
Effect of IV on DV via M (path bc)	0.03	0.063
IV's effect on M (path b)	0.14	0.294
DV effects of M (Path c)	215	215
Pathway to mediation	SC→TRUST→INTENTION	PR→TRUST→INTENTION
Effect of mediation	Yes	Yes
Mediation Degree	Partial	Partial
	H5) Supported	H6) Supported

3-6- SEM-ANN Two-Stage Approach

The SEM-ANN two-stage approach has been applied in anticipating the critical factors that precede confidence in electronic commerce, because the SEM approach only detects linear relationships by relying on compensatory models. Nevertheless, it can exaggerate complex human decision-making processes because it follows linear equations and performs the theoretical testing of models. While SEM and ANN can be integrated to test linear and non-linear relationships, relying on the compensatory model is allowed to address complexity processes in human decision-making [18].

Where the ANN approach deals with the linear and non-linear relationships because it depends on the black box process of the algorithm, which is the basis for the prediction. Therefore, both the advantages of SEM and ANN can be taken as an advantage of the shortcomings of the two approaches that have been used as a primary entry point to initiate neuronal analysis using the ANN approach [84]. The neural network is used to define a parallel, distributed processor that is composed of processing units with a neural tendency to store experimental knowledge and make it available to others. In ANN, these simple units are called neurons, just like neurons in the human body. They store and retrieve knowledge by learning processes in the communication weights of neurons just like neurons in the human body [85].

Relative Importance and Total Contribution

For this study, a Multilayer Perceptron (MLP) is used with Feed Forward-Back Propagation (FFBP). In this neural network, there are three layers (Input Layer, Hidden Layer, and Output Layer), and each layer is composed of neurons that communicate with the neurons in the other layers. Inward signals are fed forward, and errors are sent in reverse directions. As the signal passes from the input to the output, it passes through the hidden layer. A neuron computes its output based on an input vector. X The balances are represented. The components of input component-i that proceed to hidden neuron-j, are represented by W_{ji}, while the weights that proceed to hidden neuron-j from output neuron-k are represented by V_{kj} [86]. To be more specific, for the hidden neuron, the following formulas comprise.

$$net_j^h = \sum_{i=1}^{N} Wjix_i \; and \; Y_i = f\,(net_j^h) \tag{1}$$

k-th output neuron could be:

$$net_k^0 = \sum_{j=1}^{J+1} V_{kj}y_j and\; o_k = f\,(net_k^0) \tag{2}$$

It is designed to be used with a parameter in the form of an x-function (Equation 1) process the colour gamut for a function that ranges from 0 to 1, which is a monotonic and differentiable increment. The weight adjustment formula is used for the Equation 2 from which the hidden layer weights are derived. In Equation 3, d_{pk} describes the desired output of neuron-k, and o_{pk} describes the actual output of neuron-k, respectively [86, 87]. Further, weights are reduced in this way to reduce the Square of the Sum of the SSE as can be seen in Equation 6 across different training modes for some of the pre-defined tolerance levels.

$$f\,(net) = \frac{1}{1+e^{-\lambda net}} \tag{3}$$

$$V_{kj}(t+1) = v_{kj}(t) + c\lambda(d_k - o_k)o_k(1-o_k)y_i(t) \tag{4}$$

$$W_{ji}(t+1) = W_{ji}(t) + c\lambda^2 y_j\big(1-y_j\big)x_i\,(t)\Big(\sum_{k=1}^{k}\,(d_k - o_k)o_k(1-o_k)V_{kj}\Big) \tag{5}$$

$$SSE = \frac{1}{2P}\sum_{p=1}^{p}\sum_{k=1}^{k}\,(d_{pk} - o_{pk})^2 \tag{6}$$

Consequently, ANN can capture linear and non-linear correlations between variables, which gives more accurate results and summarizes in the end the contribution of each variable in the model accurately, overcoming the weaknesses in MRA, SEM, or logistical analysis, however ANN analysis is not suitable for testing hypotheses because it depends on the black box (Figure 4). To analyse the neural network, the SEM is combined with the ANN by a hypothesis testing with AMOS, after which the ANN is used. By using the sigmoid functions to activate the hidden and output layers, and by using SPSS to compute neural network algorithms, To avoid overfitting, en-fold ANNs were used for training and testing, with residual pieces of data being used for testing, Through many rounds of the learning process, errors can be reduced and prediction accuracy can be improved, including 90% that are allocated to training operations and the rest of the samples were used for testing, to avoid over processing, the probe was used ten times as much (Table 5). An ANN model's predictive accuracy is determined in order to compute the root square of the error, the root-square error RMSE was calculated [18]. Table 6 therefore indicates that the RMSE values are as follows: 0.445 for training and 0.487 for testing, and we can notice small differences between the training and testing values for the study variables, which indicates a high predictability and an excellent fit to the data and this is what is observed from the amount of weights associated with hidden neurons. While the sensitivity analysis represents an assessment of each predictor's contribution

to trust in mobile commerce the natural relative importance was calculated by dividing the part of the relative importance of each inserted neuron by the greatest relative importance (see Table 7). The results indicate that the IPC is the most important predictor of adoption of mobile commerce is followed by security and individual and trust. From the point of view of the input neuron contribution, the Internet privacy concern is the most contributing predictor, followed by individual, then security and trust. Furthermore, H (1:3) is the most contributing cell, and H (1:2) is the most inhibiting cell, followed by H (1:1). After that, the goodness-of-fit index Equation 7 is calculated to provide a comparable measure to R2 in the SEM.

$$R^2 = 1 - \frac{RMSE}{S_y^2} \tag{7}$$

The ANN model predicts 95.25 % of the adoption of mobile commerce. Where $S_y^2$is the variance of the preferred outcome based on the average of the SSE.

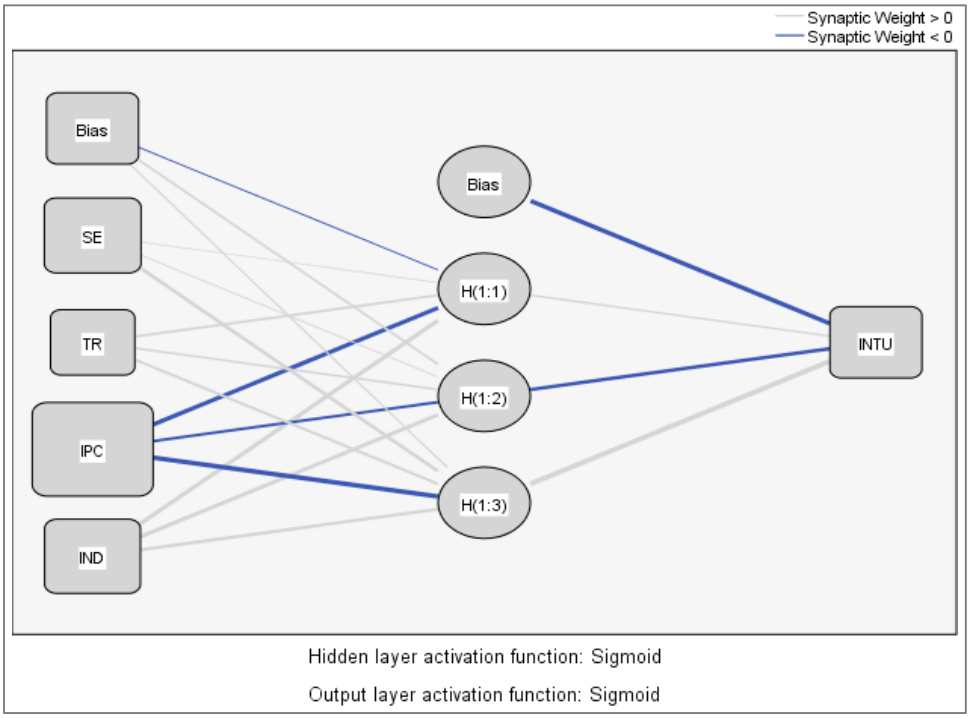

Figure 4. The ANN Model

Table 5. The relationship among the predictor variables with hidden neurons must have at least one non-zero synaptic weight

Neural Network	Input neurons: SE, IPC, IND, TR						Total
	Output nodes: INTU						
	Training			Testing			
	N	SSE	RMSE	N	SSE	RMSE	
1	785	155.231	0.445	105	24.858	0.487	890
2	800	166.711	0.456	90	19.677	0.468	890
3	797	167.924	0.459	93	20.259	0.467	890
4	805	172.261	0.463	85	19.926	0.484	890
5	801	163.312	0.452	89	18.249	0.453	890
6	799	169.337	0.460	91	22.260	0.495	890
7	795	165.686	0.457	95	20.122	0.460	890
8	801	166.337	0.456	89	17.937	0.449	890
9	793	162.139	0.452	97	21.478	0.471	890
10	803	177.418	0.470	87	20.641	0.487	890
Mean		166.63	0.457		20.54	0.4721	
SD		5.9552	0.00678		1.997	0.0156	

Table 6. Training and testing performance in terms of RMSE for a ten-fold ANN

Neural Network	Relative Importance			
	SE	TR	IPC	IND
1	0.255	0.228	0.284	0.234
2	0.261	0.216	0.280	0.242
3	0.244	0.219	0.284	0.253
4	0.265	0.220	0.270	0.245
5	0.236	0.207	0.300	0.257
6	0.251	0.215	0.292	0.243
7	0.247	0.221	0.295	0.236
8	0.259	0.224	0.281	0.236
9	0.261	0.227	0.277	0.236
10	0.248	0.218	0.286	0.248
Mean relative importance	0.2527	0.2195	0.2849	0.243
Normalized importance (%)	58.0%	36.4.0%	100.0%	56.3%

Notes: SE=Security; IPC=Internet Privacy concern; IND= Individual; TR= Trust

Table 7. Sensitivity Analysis: Neuronal average weights for hidden neurons

Parameter Estimates						
Predictor		Predicted				
		Hidden Layer 1			Output Layer	Total contribution
		H(1:1)	H(1:2)	H(1:3)	INTU	
Input Layer	(Bias)	-0.178	0.528	0.268		
	SE	0.148	0.149	0.906		1.203
	TR	0.585	0.438	0.637		1.66
	IPC	-1.164	-0.897	-2.122		-4.183
	IND	1.052	0.931	0.902		2.885
Hidden Layer 1	(Bias)				-1.235	
	H(1:1)				0.331	
	H(1:2)				-0.922	
	H(1:3)				3.504	

Notes: SE=Security; IPC=Internet Privacy concern; IND= Individual; TR= Trust

The RMSE values that are obtained from the neural network model for training and testing data points are small. Hence, the results obtained are quite accurate [88, 89]. In the ten-fold ANN, Table 7 Neuronal average weights for hidden neurons as well as input neurons. Tables 6 and 7 indicate security and trust that are the most crucial predictor of intention to use mobile commerce. However, internet privacy concern and individual are the lowest crucial predictor of intention for using mobile commerce.

4- Discussion

4-1- Direct Effects

It has been found that security plays a significant part in determining the acceptance and usage of M-commerce. Hypothesis H1 is presented, advocated and supported in this study. Security perception is positively correlated with acceptance and use of M-commerce, reflecting the growing tendency of consumers to be secure. To secure the consumers' data adequately, the confidentiality of the data must be maintained according to the security policy.

Moreover, several other studies have reported the same results [90, 91]. Besides [92] demonstrate that security possesses a direct and positive impact on the adoption of E-commerce [89]. According to [93], the m-commerce acceptance has been influenced significantly and positively by security. From this perspective, security has become a high priority consideration when adopting e-commerce [94]. Moreover, Korzaan & Boswell [95] find a strong association between privacy and security and the intention to use M-commerce. This result correlates with other studies such as Barry & Tahir Jan [96], Alqatan et al. [97], Safeena [98], and Al-Badareen [99], in which perceived security is a key variable to consider when developing M-commerce technology. If there are no appropriate security measures, consumers may not accept the facilities given by m-commerce.

IPC factors: Privacy factors include collection, secondary use, un-authorization, awareness, control, and error. The privacy concerns associated with m-commerce negatively influence acceptance and usage. There was a negative relationship between m-commerce's acceptance and usage and IPC, indicating that consumers are more concerned with privacy issues. The H3 protocol is therefore supported. Angst and Agarwal [100] provide substantial empirical evidence, which indicates the correlation between privacy concerns and behavioural intentions. Moreover, it is found to be proven that consumers with high privacy concerns are less likely to opt-in for health records. Additionally, the findings of Angst and Agarwal [100] suggest that privacy is negatively affected by its intention to use. As per the findings from Angst and Agarwal, the privacy intentions and behavioural intentions appear to be positively related. Further, when privacy concerns become extremely high, then the acceptance of m-commerce become low [101].

This result is consistent with other studies such as Rajabion [102] and Joubert & Van Belle [103]. All over, perceived privacy and security are found to be the strongest influencing factors, M-commerce providers may focus more on protecting consumers' financial information such as their credit card details to enhance m-commerce usage. In order to create a positive intention in the consumers, privacy and security are some of the pre-requisite dimensions that M-commerce providers should emphasize. Without a proper privacy and security protection, consumers will be sceptical about using m-commerce application. The findings from this study are essential for practitioners who intend to venture in an m-commerce application. This research also adds to the body of the literature the behavioral intention for using m-commerce and on the actual use of it among smartphone users.

***Individual factors**:* The model used in this study with the m-commerce acceptance and usage by consumers yields to a positive result. According to the study's proposed model, the behavioural intention explains 71% of variance where H3 is supported. Rosli et al. [37] and Enaizan et al. [104] found that individual factors should be positively associated with the intention to be used in the m-commerce industry.

The study presents and tests a model by following a two-theory model while using the SEM-ANN approach, thus arriving at an innovative model for adoption in mobile commerce with this approach, it has been discovered that UTAUT2 (Performance Expectancy; Effort Expectancy; Habit; Price Value); the IPC model (Unauthenticated; Error; Secondary Use; Collection; Control; Awareness); and security have a non-linear relationship with intention to use mobile commerce this discovery is interesting and agrees with the scientists who have researched this topic. Based on the support of the ANN, non-linear relationships among variables are discovered while the results also indicate that the UTAUT2, IPC model and security to influence adoption of mobile commerce possess a non-linear relationship, providing an insight to scientists into the future and demonstrating that consumers' perceptions of the UTAUT2. The IPC model and security interacts with the adoption of mobile commerce where a complex process is not performed and explained only by different linear relationships. Thus, when consumers realize that mobile commerce is a new trend in technology due to COVID-19 spreading, they will be eager to experiment with innovative technology and hence less hesitant to use it.

4-2- Indirect Effects

The analysis shows that trust led to privacy, security, and individual influence on the acceptance and usage of m-commerce. The existing mediation relationship is the mediation of reversal. The finding suggested that the trust play as partial mediate between IPC, individual and security and M-commerce acceptance and usage. Therefore, these findings support H5 and H6. Consequently, the best way to maintain trust and recognition of M-commerce along with consumers is the perception of the security and privacy of M-commerce [105].

The study in this paper presents and tests a model by following a two-theory model while using the SEM-ANN approach, thereby arriving at an innovative model for adoption in mobile commerce with this approach, it has been discovered that UTAUT2 (individual), the IPC model, trust, and security have a non-linear relationship with trust in mobile commerce this discovery is interesting and agrees with the scientists who have researched this topic. With the help of ANN, non-linear relationships between the variables were discovered, while the results also indicate that the interaction of trust with UTAUT2 (individual), the IPC model, and security to influence the adoption of mobile commerce also has a non-linear relationship, providing insight to scientists into the future and demonstrating that consumers' perceptions of UTAUT2 (individual), the IPC model, and security to interact with trust on adoption of mobile commerce a complex process that cannot be performed and explained only by linear relationships. Thus, when consumers realize that the mobile commerce is new trend technology of COVID-19 spreading, they will be eager to experiment with innovative technology and thus will be less hesitant to use it. Surprisingly, there is little connection between the interactions of security with intention to use mobile commerce in influencing trust in mobile commerce.

5- Limitations

Researchers have focused their attention on only one type of digital commerce structure and concluded that the results were generalizable to a number of populations. Along this, territorial partition in Jordan might also impact the understanding of mobile commerce, given the different modes of behavior of individuals in different regions. Another is the use of a general survey for the collection of data. A survey is useful for collecting statistical data, but it is not

sufficient for detailed research and exploring particular issues. Moreover, current research has a small sample size that restricts the other respondent's opinion regarding the selected research problem. Finally, various categories of consumers use mobile commerce. Consumers that are used for the conduction of the research study as digital commerce consumers need to be replicated to understand how the results can be generalized.

6- Directions for Future Research

The researcher is only focused on mobile commerce users; there are only a few empirical studies. Based upon the results of the current study, future researchers could examine a larger sample size, conduct interviews, and make observations that would provide a clearer picture of consumers' needs. Future research should also be conducted on a specific group that is involved in m-commerce, such as stakeholders and managers. The future researcher may also tackle the study from another angle by conducting pre-execution research to focus on the influences of m-commerce on stakeholders and managers.

7- Conclusion

This study uses a hybrid two-stage structural equation modelling, and neural network method to model and evaluate privacy, security, and trust in m-commerce. A survey was conducted for several customers of m-commerce in Jordan. The study population was m-commerce customers with experience purchasing online via mobile commerce applications. The current research extended UTAUT2 to attain its objectives, considering that UTAUT2 known as it has been validating by reliable significant analysis. The results that are achieved by using the UTAUT2 may be helpful as numerical findings and thus as a basis and justification for decision-makers in their decisions. The outcome can also be contributive towards the M-commerce application developers' knowledge of enhancing existing M-commerce applications based on the application's weaknesses highlighted by the study.

The AMOS-SEM technique validated the relationship between privacy, security, and trust factors and the intention to use m-commerce. When perceived novelty was high, the relationship between privacy, security, and trust in m-commerce was significant. Additionally, there is a relationship between privacy, security, and trust in the intention to use m-commerce. The trust mediates the relationship between privacy and security with the intention to use m-commerce. On the other hand, the ANN approach revealed that security is the most significant predictor of intention to use m-commerce.

8- Declarations

8-1- Author Contributions

Conceptualization, O.E., A.S., B.E., M.A., and G.A.A.; methodology, O.E., A.S., B.E., M.A., and G.A.A.; writing—original draft preparation, O.E., A.S., B.E., M.A., and G.A.A.; writing—review and editing, O.E., A.S., B.E., M.A., and G.A.A. All authors have read and agreed to the published version of the manuscript.

8-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

8-3- Funding

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8-4- Acknowledgements

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8-5- Institutional Review Board Statement

Not applicable.

8-6- Informed Consent Statement

Informed consent was obtained from all participants of the study.

8-7- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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