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Integrating the Internet of Things Into E-Commerce: The Role of Trust, Privacy, and Data Confidentiality Concerns in Consumer Adoption

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ABSTRACT

The emergence of the internet of things (IoT) is changing the behavior of people, companies, and their businesses. The IoT can enhance e-commerce by reducing the gaps between the virtual and physical worlds. Although the integration of the IoT into e-commerce has several positive effects, security concerns are greater in the IoT context than in traditional e-commerce settings. The proposed research model is based on the unified theory of acceptance and use of technology 2 (UTAUT2) along with trust, privacy, and confidential data concerns to explain the intention to use the IoT in e-commerce. The authors developed a questionnaire and received a total of 328 responses. The results show that among the IoT security factors, trust and privacy are significant determinants of the intention to use the IoT in e-commerce.

KEYWORDS

Data Confidentiality, E-Commerce, Internet of Things, Privacy, Technology Acceptance Models, Trust

INTRODUCTION

Globalisation has given rise to a competitive business environment. Every day, technologies improve to meet the needs of global users. The internet provides access to information through different devices (Cortés et al., 2015) and internet of things (IoT) improves access to distinctive services, as well as enhances opportunities to communicate and exchange data. IoT can be defined as “a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies” (ITU, 2012, p. 2). Inevitably, the devices in IoT capture large amounts of diverse data, which facilitates new forms of communication between people and smart objects or between objects (Cortés et al., 2015).

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The incorporation of IoT technologies in e-commerce is an innovative driver for e-commerce retail (Bayer et al., 2021). IoT reduces natural gaps between the virtual and physical worlds. For example, IoT can facilitate more efficient inventory management through radio-frequency identification (RFID). These smart tags or smart shelves help firms optimise inventory levels and avoid out-of-stock products. Firms can also apply IoT to streamline the supply chain management by tracking and controlling the delivery of products. Furthermore, this technological innovation can improve customers' e-commerce experience.

Amazon Dash allows customers to remotely reorder products with the press of a button. Overall, it changes the way customers buy online (Farah & Ramadan, 2017). Tesco subway stores in South Korea integrate IoT with e-commerce. Tesco (or Homeplus in South Korea) allows customers to shop as they wait for their subway train (Ju & Li, 2011). With a mobile app, customers can scan the product barcode, add the product to the digital shopping cart, and pay for it via the app. Products are then delivered to their home (Ju & Li, 2011). Another example is the smart mirror, which allows customers to virtually try on an outfit before ordering it online. Other examples include wearables, beacons, sensors, and smart speakers like Amazon Alexa. Overall, these IoT applications change consumer behaviour. Bayer et al. (2021) proposed a set of opportunities that IoT may offer to e-commerce customers, including "context-aware services, natural interaction, and automated customer processes" (p. 1).

The integration of IoT into e-commerce has several positive effects on customers and retail organisations. Still, there is a trade-off between convenience and privacy. Privacy concerns are higher in the IoT context when compared to traditional e-commerce settings. For example, IoT includes a set of technologies that capture and store diverse types of personal and activity data. Amazon acknowledged that its workers hear what is told to Alexa and Echo records Alexa's homeowners (Day et al., 2019). Those recordings are sometimes listened to and transcribed by Amazon employees (Day et al., 2019). Then, the data are used to enhance Alexa's intelligence and accuracy in recognising human speech (Day et al., 2019). More importantly, as speech data are being recorded and stored, they could be used to perform data mining to influence user behaviour.

According to research, users and potential users have concerns about the invasion of privacy in the home environment. Thus, it demonstrates resistance toward its adoption (Lee, 2020). In the context of IoT, data confidentiality, privacy, and trust are more critical than in traditional e-commerce.

There are several studies about the adoption of IoT technologies (Miorandi et al., 2012; Yu et al., 2015). However, few studies focus on the use of IoT in e-commerce. Although e-commerce is not new, it has adapted several technological advancements into the business model. In fact, e-commerce can leverage IoT technologies to create a stronger value proposition and experience for users. By connecting objects, devices, and people, IoT technologies can improve and innovate e-commerce business models (Yao et al., 2015). Additionally, it is important to understand the effect that the use of IoT may have on consumers' lives (Bayer et al., 2021).

This study contributes to the understanding of user adoption of new services and interactions provided by IoT technologies in e-commerce. It also explores the effects of trust, privacy, and confidential data concerns in explaining consumer intention to use IoT in e-commerce. This study argues that the acceptance of IoT in the context of e-commerce differs from traditional e-commerce given its complex technology. It also differs from the adoption of IoT in other contexts in which IoT is used for purposes other than purchases. Thus, this study intends to answer the following research questions:

1. What factors influence the use of IoT technologies in e-commerce?
2. What is the role of security in e-commerce with IoT?

The remainder of this study is organised into six distinct sections. First, the article provides a literature review. Then, it explores the conceptual model development and research hypotheses. The

methodology, data analysis, and results are presented. Finally, the article includes a discussion and conclusion.

LITERATURE REVIEW

IoT and E-Commerce

Chaffey (2011) defined e-commerce as all information exchanged electronically between an organisation and its external stakeholders. E-commerce was once limited to presenting catalogues and products online. However, the expansion of the internet offers interactive and safe digital environments that transform e-commerce activities from a single buyer-seller interaction to connections (Chu et al., 2007).

Successful e-commerce businesses have benefited from the waves of technological innovation. Over the years, e-commerce has incorporated technological innovation to reinvent itself (Fleisch, 2010). Recent e-commerce developments include mobile commerce and social commerce. These developments may require adaptations of traditional e-commerce to new consumer demands as more consumers adopt mobile technologies and social media platforms.

IoT links objects that are offline in the current e-commerce business model and generates an unprecedented amount of data on their status, product performance, and consumer behaviour and preferences. (Yao et al., 2015, p. 247)

An object is considered “smart” if it can be identifiable and is able to communicate and interact with other objects, systems or people (Miorandi et al., 2012). IoT provides an omnipresent presence around people, things, or objects that, through unique schemes, can interact, communicate, and cooperate with each other to achieve specific goals (Atzori et al., 2010). In this sense, e-commerce can benefit from IoT technologies to innovate and make the transaction process more flexible, convenient or even fun. This, in turn, enhances customer experience by, for example, using IoT technologies in omnichannel commerce to create a personalised, seamless shopping experience (Kaczorowska-Spychalska, 2017).

The concept of “commerce of things” represents the convergence between e-commerce and IoT to meet users’ needs and expectations in terms of the convenience of a virtual shopping experience (Grau, 2013). On that convergence, e-commerce revenue models leverage IoT’s unique value propositions of customer convenience, information sharing, and innovation driver “to expand from facilitating online transactions to transforming shared information into knowledge with practical implications” (Yao et al., 2015, p. 248).

For example, the commerce of things uses smart devices to tell when a product should be acquired according to the criteria supplied by consumers. This example of an autonomous action releases the user from the obligation to “spend” time and effort performing tasks without the inconvenience of running out of a product (Guo et al., 2017). Moreover, Guo et al. (2017) proposed that IoT has a positive effect on e-commerce in terms of the quality of logistics activities, quality of products, management of the supply chain, and flow of capital. These correspond to the integration of business processes that support e-commerce activities but do not consider the interfaces and interactions of users.

Transactions are becoming more intuitive (and almost invisible) to the consumer (Sellebråten et al., 2015). Although users do not see those activities or communications, they do not compromise the consumer’s relationship with the brand. An objective of the commerce of things is to create a strong, lasting relationship with users through intelligent data (Caro & Sadr, 2019). However, the ubiquity, high convenience, and instantaneous digital shopping experience may induce impulsive buying that most consumers later regret because they correspond to a change in the normal rational decision-making process (Lim et al., 2017). Additionally, compromising security and privacy to access more

personalised services and enhanced convenience could lead to the risk of being manipulated by brands (Zuboff, 2015) to induce impulsive buying behaviour.

IoT and E-Commerce Studies

Researches on IoT are mainly applied to the supply chain and its use to optimise supply chain management using RFID (Ruan & Shi, 2016; Yu et al., 2015). Although IoT and RFID are related, they are not the same. RFID is a technology that transmits and identifies objects and people through radio waves. It is one of the key factors in the construction and implementation of IoT (Chong et al., 2015). However, IoT is a broader concept that includes other forms of connecting devices and people.

Most research on the acceptance and adoption of IoT technologies does not consider their use in the context of e-commerce. Gao and Bai (2014) developed a nomological network for the antecedents of the acceptance of IoT based on the technology acceptance model (TAM). This model shows the effects of perceived usefulness, perceived ease of use, social influence, perceived enjoyment, and perceived behavioural control on the intention to use a specific application of IoT, the electronic toll collection (ETC). This application uses passive RFID technology to digitally collect tolls on roads or plazas. Rothensee (2008) studied an acceptance model for an intelligent refrigerator, concluding that social life and the habit of use can influence the user to accept an IoT product. In another study, Hong (2016) developed a framework that can measure the acceptance factors of IoT products. The study proposes a conceptual model in which the influencing factors are grouped into social, cultural, and monetary environments. Al-Momani et al. (2016) proposed a conceptual model based on TAM and the unified theory of acceptance and use of technology (UTAUT) applied to IoT technologies motivated by the fact that all previous studies only referred to more technical aspects of the technology and neglected the user. Farah and Ramadan (2017) studied the effect of Amazon Dash on consumer buying patterns. It does not, however, assess the intention to use IoT technology within an e-commerce purchase. The study finds that the perceived value of Amazon Dash positively affects the consumer's impulsiveness and feeling toward the seller. In turn, it is negatively affected by the consumer's self-control in spending. Kalyani (2017) presented different settings for IoT applications in e-commerce, as well as an overview of the technical architecture of IoT and its challenges related to security, trust, privacy, standards, regulatory issues, and applications.

In summary, IoT in e-commerce is changing business and customer experience. Its advanced business models facilitate faster supply chain operations, support automated sorting centres, and develop smart inventory systems. In addition, it provides customers with personalised experiences. For example, it uses recommendation systems to track customer feedback on products to better understand customer needs and preferences (Karn et al., 2022). Although, several studies addressed different aspects of the integration of IoT with e-commerce, no study has tried to understand the acceptance of IoT by users in the context of e-commerce.

Security in the Context of IoT

The literature usually describes the architecture of IoT as having several layers of implementation that may involve many players. Its fragmented environment has different standards within various architectural layers. These raise more potential vulnerabilities and to be effective, security must be implemented in the layers of IoT.

E-commerce applications with IoT have unique security challenges when compared with other information technologies (Kalyani, 2017). Its vulnerabilities may have a greater negative effect, "especially as this technology becomes more pervasive and integrated into our daily lives" (Kalyani, 2017, p. 539). Security is also a critical factor in the adoption of IoT (Miorandi et al., 2012). According to Miorandi et al. (2012), "without guarantees in terms of system-level confidentiality, authenticity, and privacy, the relevant stakeholders are unlikely to adopt IoT solutions on a large scale" (p. 1505).

Given the type and amount of data collected by IoT technologies, trust and privacy are critical for providing a superior customer experience. Miorandi et al. (2012) developed a security framework for IoT with the following dimensions:

1. **Data Confidentiality:** Data confidentiality is the process of controlling access and managing identity that preserves confidentiality.
2. **Privacy:** Privacy is related to the processes of enforcement mechanisms, role-based systems, and data governance.
3. **Trust:** Trust includes negotiation mechanisms and languages that “exploit digital identity information for the purpose of providing a fine-grained access control to protected resources” (Miorandi et al., 2012, p. 1508).

MODEL AND HYPOTHESES DEVELOPMENT

Understanding the acceptance and use of a certain technology is one of the most mature topics in information systems (IS) research. The UTAUT2 is a theory developed by Venkatesh et al. (2012) on the acceptance of information technology in a commercial and hedonic context. This research uses UTAUT2 as a theoretical support for the adoption of IoT in e-commerce within a commerce and hedonic context. UTAUT2 is a comprehensive framework that has been widely adopted to explain individual behaviour regarding IS usage in consumer contexts.

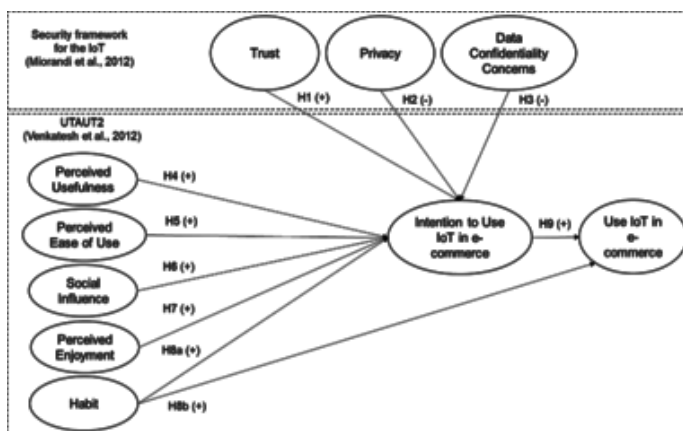
Following Gao and Bai (2014)’s study on the adoption of IoT technologies, this study develops a model for the antecedents and intention to use IoT technologies in e-commerce. The main objective of this study is to understand the role of security concerns in the context of adopting IoT in e-commerce. Therefore, this study builds on the security framework for IoT proposed by Miorandi et al. (2012) to define the key security challenges in terms of data confidentiality, trust, and privacy. Figure 1 presents the research model and hypotheses (the expected relationship sign is in parenthesis).

Trust

Trust (T) can have different definitions depending on the context in which it is applied (Gefen et al., 2003). Trust can be defined as a negotiation process in which credentials are exchanged between parties (Miorandi et al., 2012). In the e-commerce context, trust is “an expectation that others one chooses to trust will not behave opportunistically by taking advantage of the situation” (Gefen et al., 2003, p. 54). Trust may lower the risk perception associated with the use of a certain technological innovation. According to Gao and Bai (2014), IoT has specific and unique technological characteristics that increase the sense of uncertainty and risk. Thus, consumer trust plays an important role in facilitating the adoption of IoT.

Furthermore, trust helps to reduce the social complexity that users face in e-commerce. IoT technologies cause the user to exclude potential undesirable behaviours, such as the inappropriate use

Figure 1.



of their information when performing e-commerce transactions (McKnight et al., 2002). Trust in IoT technologies is especially important given the fact that not all transactions are visible. Research has found that trust is a significant antecedent of the perceived usefulness of IoT technologies (Gao & Bai, 2014). Indeed, this study emphasises that trust encourages users to perform online purchases and it can influence the intention to use IoT in those purchases. Given this, the study proposes the following hypothesis:

H1: Trust positively influences the intention to use IoT technologies in e-commerce.

Privacy

Privacy (PR) can be defined as “the rules under which data referring to individual users may be accessed” (Miorandi et al., 2012, p. 1507). Therefore, information privacy is an individual’s desire to protect and control information about themselves (Bélanger & Crossler, 2011; Pavlou et al., 2007). This is critical to IoT technologies in e-commerce (Wang et al., 2003).

Other e-commerce studies indicate that security and privacy issues influence the adoption of new technologies (Im et al., 2008). Moreover, the large amount of data collected may represent a privacy threat to users, particularly in-home assistants like Amazon Alexa (McLean & Osei-Frimpong, 2019). In fact, several studies pointed out that privacy concerns are a barrier to e-commerce (Pavlou et al., 2007). Consumers may consider that IoT technologies are the next step toward enhanced convenience. However, the integration of intelligence into interconnected objects in consumer life may prove to be a potential threat to privacy (Atzori et al., 2010). These perceptions may impact the intention to use. Therefore, this study proposes the following hypothesis:

H2: Privacy concerns negatively influence the intention to use IoT technologies in e-commerce.

Data Confidentiality

Technological advancements encourage consumers to shop in smart environments and online environments. The acceptance of these environments can be determined by the need for control that is motivated by the intention to perceive the reasons and consequences of a user’s behaviour (Noone et al., 2012). As such, this loss of control can influence the intention to use or the acceptance of the new technology due to existing vulnerabilities. Some users have fear when they do not know or do not control what happens to the information they provide (McLean & Osei-Frimpong, 2019; Suh & Han, 2003).

Among information control is the control that personal data are accessed only by authorised subjects and organisations. In the IoT context, Miorandi et al. (2012) indicated that data confidentiality (DC) in terms of authorised access to user data is of major importance regarding the acceptance of IoT. In fact, purchase data and payment information are often considered sensitive user information that is used in e-commerce with IoT. Thus, this study puts forward the following hypothesis:

H3: Perceived concerns about data confidentiality negatively influence the intention to use IoT technologies in e-commerce.

Perceived Usefulness

Research shows that users accept innovations and novel technologies if they have a unique advantage over an existing solution (Rogers, 2003). From a utilitarian point of view, if the new technology is not perceived to be useful, the user will not see its advantage over existing ones. Perceived usefulness (PU) of IoT in e-commerce is the degree to which a consumer believes that using IoT technologies like Amazon’s Dash buttons when they are making online purchases would increase their purchase performance by facilitating transaction procedures.

IoT technologies introduce new e-commerce services that result in savings of time and money for the consumer (Gregory, 2015). In this way, IoT's usefulness may influence the intention to use it in e-commerce because it is an advantage over other technologies. Thus, the study proposes the following hypothesis:

H4: Perceived usefulness positively influences the intention to use IoT technologies in e-commerce.

Perceived Ease of Use (PEOU)

PEOU is an important factor in accepting new technologies (Davis et al., 1989; Venkatesh et al., 2003). To prevent the underutilisation of a system or technology, it needs to be easy to understand and easy to use (Wang et al., 2003). If it is easy to use, it will be less intimidating for the individual to decide whether to use it (requires less effort to use it). As such, PEOU represents effort expectancy from UTUAT2.

IoT technologies in e-commerce aim to facilitate ease in the life of the user. These represent an opportunity and a benefit (Gregory, 2015). Therefore, it can be said that ease of use influences consumers' intention to use IoT technologies in e-commerce. Thus, the next hypothesis is:

H5: PEOU positively influences the intention to use IoT technologies in e-commerce.

Social Influence

Social influence (SI) is defined as the level at which individuals perceive that important people in their life believe they should use the new technology or system (Venkatesh et al., 2003). In this way, the social context is an important influencing factor in the process of accepting technology.

The development of IoT technologies is at an early stage. However, it will continue to develop, especially in the context of the application of IoT technologies to e-commerce as the opinion of others plays an important role in influencing new users. Social influence affects the consumer's perceptions of IoT technologies through the internalisation and identification with others' opinions and beliefs about the technology. This triggers an individual reaction to potential social gains of using IoT technologies in e-commerce purchases (Venkatesh et al., 2003). Given that, social influence is relevant to the intention to use IoT by new consumers because it influences its adoption in e-commerce. Thus, the next hypothesis is:

H6: Social influence positively influences the intention to use IoT technologies in e-commerce.

Perceived Enjoyment

Perceived enjoyment (PE) may motivate the user to accept new technologies (Venkatesh et al., 2012). In the context of IoT in e-commerce, perceived enjoyment is the degree of fun and pleasure that exists when the individual uses IoT technologies (Gao & Bai, 2014), which is similar to UTAUT2's hedonic motivation. McLean and Osei-Frimpong (2019) find a positive relationship between perceived enjoyment and the intention to use home digital assistants. The design of new technologies and initiatives in e-commerce should be pleasurable and fun for the consumer, so this factor can positively influence the intention to use those new technologies such as IoT. Thus, the study proposes the following hypothesis:

H7: Perceived enjoyment positively influences the intention to use IoT technologies in e-commerce.

Habit

Habit (H) is "the extent to which people tend to perform behaviours (use IS) automatically because of learning" (Limayem et al., 2007, p. 709). It directly affects the intention to use as discussed in previous

studies (Kim & Malhotra, 2005; Limayem & Hirt, 2003; Venkatesh et al., 2012). This factor incorporates the perspective that the automatic actions of users influence their behaviours (Venkatesh et al., 2012). Research shows that the direct effect of habit on technology use can be stronger than the effect of intention to use. Furthermore, with increasing habit, intention becomes a less important predictor of use (Venkatesh et al., 2012). IoT is a technology that seeks to be present in daily life; therefore, the repetitive execution of using it can give users of e-commerce enhanced convenience and can influence their intention to use it (Rothensee, 2008). In line with this reasoning, this study proposes the following hypotheses:

H8a: Habit positively influences the intention to use IoT technologies in e-commerce.

H8b: Habit positively influences the use of IoT technologies in e-commerce.

Use Intention

The intention to use a future product or service is defined as the will of an individual to use or continue to use a particular technology (Venkatesh et al., 2012). The effect of intention to use a given technology decreases as users gain experience with that technology. IoT in e-commerce is still in the early stages of acceptance; therefore, it is expected that intention to use IoT is a strong predictor of use. This study proposes the following hypothesis:

H9: The intention to use positively influences the use of IoT technologies in e-commerce.

METHODOLOGY

To assess the research hypotheses, the research model was operationalised with a questionnaire based on existing scales. Then, data were collected through Amazon Mechanical Turk. Finally, the collected data were analysed with SmartPLS3.0 (Ringle et al., 2015).

Measures

The operationalisation of the constructs was made by adapting measures from previous studies. The items for each construct are shown in Appendix A. The scale for trust was adapted from Gefen et al. (2003) and McKnight et al. (2002). The privacy scale was drawn from Thiesse (2007). The scale for data confidentiality concerns was adapted from Noone et al. (2012).

Regarding the scales for the UTAUT2 constructs, perceived usefulness was adapted from Gao and Bai (2014), perceived ease of use from Wang et al. (2003) and Davis et al. (1989), social influence from Venkatesh et al. (2003), perceived enjoyment from Davis et al. (1989), and habit, intention to use, and use from Venkatesh et al. (2012). All items were measured using a seven-point Likert scale: strongly agree (1), agree (2), agree a little (3), neither agree nor disagree (4), disagree a bit (5), disagree (6), and strongly disagree (7). All constructs were reflective. Only use was modelled as a formative construct in the original scale.

Instrument Development

The questionnaire was implemented on Qualtrics. A pre-test was performed with five respondents to improve the questionnaire. As a result, small changes were made to the questionnaire in terms of vocabulary and structure. Subsequently, to test the quality of the measurement model, a pilot test was carried out with 20 additional respondents. The results showed that no further changes were necessary.

Sample

The questionnaire focused on a very recent technology. Therefore, the study collected the data through an online platform provided by Amazon, the Mechanical Turk. This platform provided access to an

international pool of respondents who tend to buy products online. Therefore, these individuals could be among the earlier adopters of IoT in e-commerce.

Mechanical Turk is an online crowdsourcing service that coordinates the supply and demand of jobs that require human intelligence (Paolacci et al., 2010). The platform is a labour market in which users (requesters) recruit workers to perform specific tasks. In general, Mechanical Turk formalises job offers for thousands of workers who can do the job as they see fit (AWS, 2017). For each job performed, workers receive monetary compensation as was previously defined by the user who requested the work (Lee et al., 2014).

The final sample comprises 328 valid responses. The respondents were mainly males (59.8%). Most were between 25 and 40 years of age. Interestingly, 95.4% of the individuals used e-commerce to make online purchases. The data also indicated that about 47% had an undergraduate academic degree. Table 1 presents the descriptive statistics of the final sample.

RESULTS

The research model was tested with partial least squares (PLS) using Smart PLS 3.0 software (Ringle et al., 2015). PLS allows the analysis of models with latent variables and test the theoretical hypothesised relationships (Pavlou, 2003). Additionally, PLS is adequate to test models with formative latent variables (Henseler et al., 2009). Common method bias could influence the results of the present study. Therefore, the existence of CMB was checked before testing the model. The Harman's single-factor test (Podsakoff et al., 2003) was applied to verify if a common factor could explain a

Table 1.
Sample descriptive statistics (n = 328)

Characteristics	Frequency	%
Gender		
Male	196	59.8%
Female	132	40.2%
Age		
18-24	53	16.2%
25-30	97	29.6%
31-40	99	30.2%
> 40	79	24.1%
Education Degree		
Not graduated	67	20.4%
Bachelor's	154	47%
Post-graduation	23	7%
Master's	64	19.5%
PhD	9	2.7%
Other	11	3.4%
Use of E-commerce		
Yes	313	95.4%
No	15	4.6%

significant amount of variance in the data. The total variance for a single factor is 49% (less than 50%). This percentage indicates that common method bias is not likely to affect the data or results.

Measurement Model

To evaluate the reflective measurement models, reliability and validity should be tested (Henseler et al., 2009). Internal reliability consistency was verified with Cronbach’s Alpha and composite reliability. For internal reliability, Cronbach’s Alpha and composite reliability values must be greater than 0.7 (Henseler et al., 2009). Considering these criteria, all latent variables present a satisfactory internal reliability consistency because all values are greater than 0.7 (see Table 2).

Several tests were performed to evaluate the convergent and discriminant validity of the measurement model. Convergent validity indicates that a set of indicators is part of the same construct (Hair et al., 2017). Average variance extracted (AVE) is the criterion used evaluate convergent validity. According to AVE, variables with values equal to or greater than 0.5 indicate a satisfactory convergent validity. This means that, on average, a latent variable can explain more than half of the variance of their indicators. Taking this analysis and the values presented in Table 2 into account, the study concludes that the measuring instrument has good convergent validity because all constructs present AVE values greater than 0.5 (see Table 2).

To evaluate the discriminant validity, the study uses the criteria of Fornell-Larcker (see Table 3) and cross-loadings (Hair et al., 2017). Regarding the first criterion, the square roots of the AVE values of each construct are compared with the correlations between the other constructs. The discriminant validity is verified when the square roots of the AVEs are higher than the correlations between the constructs. According to the values presented in Table 3, this criterion is fulfilled. Cross-loadings also show adequate discriminant validity of constructs as each item the loading values were greater in the assigned construct.

To further test for multicollinearity, the study computes the variance inflation factors (VIFs) and tolerance (see Table 4) for indicators U1 and U2. These operationalise the formative construct “Use of IoT in E-commerce.” The VIFs are around two. They are less than the conservative threshold of five. Tolerance values are around 0.3, so higher than the threshold of 0.2. These values indicate that multicollinearity is not a major issue in the study regarding this formative construct.

Table 2.
Reflective measurement model quality criteria

Construct	AVE	Composite Reliability	Cronbach Alpha
Perceived Usefulness	0.893	0.944	0.883
Perceived Ease of Use	0.879	0.936	0.871
Trust	0.933	0.965	0.928
Social Influence	0.811	0.928	0.884
Perceived Enjoyment	0.845	0.942	0.910
Data Confidentiality Concerns	0.931	0.964	0.926
Privacy	0.847	0.943	0.959
Habit	0.852	0.920	0.831
Intention to Use IoT in e-commerce	0.765	0.928	0.914

Table 3.
Fornell-Larcker criterion

	T	CC	PR	PE	PEU	H	SI	UI	PU
T	0.966								
CC	-0.341	0.965							
PR	-0.409	0.816	0.920						
PE	0.614	-0.166	-0.200	0.919					
PEU	0.413	-0.025	-0.082	0.593	0.938				
H	0.675	-0.180	-0.224	0.634	0.496	0.923			
SI	0.685	-0.198	-0.257	0.649	0.515	0.632	0.901		
UI	0.726	-0.272	-0.345	0.718	0.512	0.830	0.669	0.874	
PU	0.615	-0.143	-0.173	0.625	0.574	0.635	0.653	0.698	0.945

Notes: The diagonal values represent the square root of AVE and the off-diagonal values are the correlations between a construct and other constructs: Trust; CC: Data Confidentiality Concerns; PR: Privacy; PE: Perceived Enjoyment; PEU: Perceived Ease of Use; H: Habit; SI: Social Influence; UI: Intention to Use IoT in E-Commerce; PU: Perceived Usefulness.

Table 4.
Reflective measurement model quality criteria

Item	Weight Significance	Collinearity	
	Outer Weight	VIF	Tolerance
U1	0.546	2.030	0.493
U2	0.534	2.030	0.493

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Structural Model

Table 5 presents the results of the structural model. To assess the statistical significance of the research hypotheses, the significance tests were carried out in the PLS software using bootstrapping with 5,000 iterations. The structural model is evaluated with the significance and relevance of the path coefficients (see Table 5), and R^2 values (see Figure 2).

Finally, regarding the relevance of the coefficients, f^2 is calculated to verify the size effect of the exogenous latent variables to explain R^2 . The three thresholds for size effect (0.002, 0.15, and 0.35) correspond to the small, medium, or large effect (Hair et al., 2017). All variables had a weak effect on intention of use and use (less than 0.015), except for habit's highest value ($f^2 = 0.486$) on use intention and use intention on use (with a high effect of $f^2 = 0.943$).

Therefore, according to the structural model results, this model explains 80% and 84% of "Intention to Use IoT in E-Commerce" and the "Use of IoT in E-Commerce," respectively. It represents a strong capability to explain the endogenous variables (Hair et al., 2017). In analysing the significance of the path coefficients of the hypothesised relationships, only H3, H5, and H6 have no support. The remaining hypotheses (H1, H2, H4, H7, H8a, H8b, and H9) are supported.

DISCUSSION

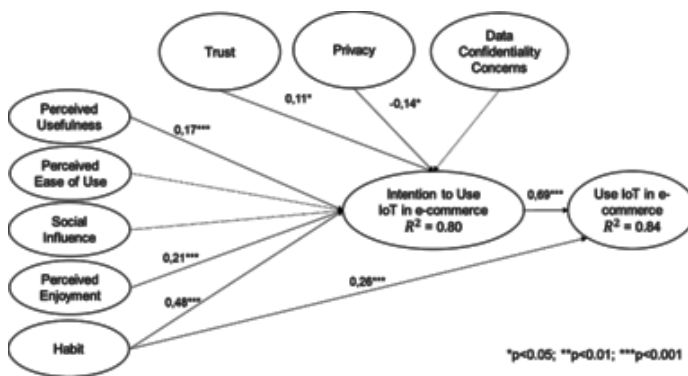
This study aims to understand the adoption of IoT in e-commerce. It focuses on the specific role of security challenges in the context of adoption. According to the study, security dimensions are

Table 5.
Structural model results

	Intention to Use IoT in E-Commerce		Use IoT in E-Commerce	
R^2	0.80		0.84	
R^2 (Adj.)	0.79		0.84	
	Path Coefficient	f^2	Path Coefficient	f^2
Trust	0.11*	0.02	-	-
Privacy	-0.14**	0.03	-	-
Data Confidentiality Concerns	0.03	-	-	-
Perceived Usefulness	0.17***	0.06	-	-
Perceived Ease of Use	-0.02	-	-	-
Social Influence	0.02	-	-	-
Perceived Enjoyment	0.21***	0.09	-	-
Habit	0.48***	0.49	0.26***	0.13
Use Intention	-	-	0.69***	0.94

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Figure 2.



important in explaining the adoption of IoT in e-commerce. Therefore, the proposed model is a more complete framework for understanding the adoption and use of this type of technological innovation. Based on Miorandi et al. (2012), the framework comprises trust, privacy, and data confidentiality concerns as security constructs, along with UTAUT constructs.

This study shows that privacy concern is the strongest security factor in influencing the intention to use IoT in e-commerce. Privacy has a negative effect on intention to use when considering security concerns of users. This is in line with other studies, such as Borgia (2014) and McLean and Wilson (2019). Additionally, trust is a positive and significant antecedent of the intention to use, confirming that users who trust the technology are willing to rely on IoT mechanisms in e-commerce. This is in accordance with other studies, such as Pavlou et al. (2007) and Son and Kim (2008). In the context of

IoT in e-commerce, the unique characteristics of the technology may induce higher levels of perceived risk. Therefore, consumer trust aids in overcoming barriers.

The present research finds that habit, perceived enjoyment, and perceived usefulness are positive determinants of the intention to use IoT in e-commerce. These results are in line with other studies, such as Davis et al. (1989), Gao and Bai (2014), and Venkatesh et al. (2012). The constructs are important and influential determinants for the acceptance of a new technology. Nair et al. (2015) pointed out that the greater the habit, the greater the intention to use a technology. The use of new technologies is a repetitive and automated act. Thus, the more a new technology is used, the greater the intention to continue its use (Dutot, 2015). Perceived enjoyment also has a positive effect on intention to use. This result indicates that respondents view satisfaction or enjoyment as an important factor in accepting IoT technologies in e-commerce. Regarding perceived usefulness, this result is in accordance with Gao and Bai (2014), who also found that usefulness is influential when one technology has an advantage over alternative options. This advantage highlights the fact that IoT technologies help e-commerce users.

Surprisingly, concerns about data confidentiality were not a significant antecedent of the intention to use. This factor refers to the control that a user has over the subsequent use of personal information. The lack of knowledge regarding what happens to personal information during a transaction or after purchases may not affect the consumer's intention to use IoT in e-commerce. This can be explained by the consumer's trust in e-commerce mechanisms that assure data confidentiality in commercial transactions. In addition, the introduction of IoT may not imply additional concerns because no data collection is required by the use of IoT.

Ease of use is the intuitive user's perception of the effort that the system or technology requires. In this study, ease of use did not have a statistically significant effect on the intention to use. Studies about the adoption of new technologies like wearable devices show ambiguous results regarding the effect of perceived ease of use on intention to use, perceived usefulness, and attitude (Gopinath et al., 2022). This might be explained by the fact that new technologies are easier to use because usable interfaces reduce user effort in new generations of technologies.

Accepting IoT technologies requires users to be skilled on using the internet and assessing their own IoT skills (de Boer et al., 2019). Research shows that users skills regarding innovative uses of technology can be similar across different profiles of users (Martins et al., 2022). The sample was comprised of e-commerce shoppers who, most likely, have already overcome technology barriers.

Social influence is not a significant antecedent of the intention to use IoT technologies in e-commerce. This result can be explained by the fact that these technologies are new. Therefore, users are curious to try them even if their closest acquaintances and peers do not use them. This is, however, contrary to research by Gao and Bai (2014). Further research is needed to clarify the importance of social influence on the adoption of IoT.

Theoretical Contributions

Our study incorporates consumer security concerns regarding the use of IoT in e-commerce in UTAUT2 considering the security framework for IoT proposed by Miorandi et al. (2012). The framework includes three dimensions of security, data confidentiality, trust, and privacy, however, our study reveals that contrary to trust and privacy, data confidentiality is not a relevant security concern of consumers when using IoT technologies in e-commerce. Second, our research confirms that even in the context of the introduction of new technologies in established ones like e-commerce, habit continues to be the main antecedent of intention to use and use. Finally, the present study contributes to the increase of scientific knowledge regarding the user acceptance of IoT, mainly in a context that previously had not yet been studied, e-commerce. It also provides results to understand the difference between more traditional e-commerce initiatives and e-commerce initiatives integrated with IoT technologies, where the "fun" expectations are higher as it is a newer technology that can foster more innovative customer experiences.

Practical Contributions

The current research shows that the factors with a greater influence on the use of IoT technologies in e-commerce are habit, perceived enjoyment, and perceived usefulness. The “fun” associated with the use of this technology and its usefulness is the most influential determinant of the use of IoT technologies in the context of e-commerce. Therefore, developers and organisations willing to integrate IoT technologies into their e-commerce systems should give importance to the hedonic aspects of this integration, focusing on the usability and interactivity that this integration can provide.

The study also found that trust and privacy concerns are significant in explaining the intention to use IoT technologies in e-commerce. In fact, the nature of this technology and the sense of a lack of control over the information that is gathered and used in this environment could prevent some users from experimenting with this technology. Organisations should ensure the privacy of their clients through transparent, informative communication that discloses the data is going to be collected from the user and how this data is going to be used. This upfront attitude could enhance the trust that users have in a brand or organisation.

CONCLUDING REMARKS

This study attempts to answer the following research questions:

1. What factors influence the use of IoT technologies in e-commerce?
2. What is the role of security in e-commerce with IoT?

This study developed and tested a research model with data collected through an online survey on Amazon Mechanical Turk. The findings reveal the positive effect of trust and negative effect of privacy on the intention to use IoT in e-commerce. Additionally, intention to use IoT in e-commerce is positively affected by perceived usefulness, perceived enjoyment, and habit.

This study has several contributions to the theory and practice; however, it also presents limitations. First, the sample was obtained through an online crowdsourcing platform. This may not be representative of the population or could be biased given the amount paid to each respondent. Second, other constructs could be considered relevant for understanding the intention to use IoT in e-commerce websites. Third, future studies could focus on a single market or a specific IoT technology. Fourth, research could investigate the role of IoT in e-commerce based on recent developments in the metaverse. Studies like Jeong et al. (2022) explore the integration of e-commerce in the metaverse. IoT could be integrated with e-commerce to enhance user experiences in this context because it improves the integration between the physical and virtual worlds.

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