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E-B Environment - Behaviour Proceedings Journal

AicQoL2025Pangkor

https://www.amerabra.org/
13th AMER International Conference on Quality of Life,
Puteri Bayu Beach Resort, Pangkor Island, Malaysia.

e-IPH e-International Publishing House Ltd., United Kingdom

Modelling a Sustainable Digital Economy among E-Commerce Users in Indonesia

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Abstract
Indonesia's digital economy has been driven by solid internet connectivity, widespread smartphone use, and growing e-commerce platforms. However, the digital implementation gap affects equitable access to technology and digital skills across various age groups. This research investigates factors influencing sustainable digital growth among urban e-commerce users in Indonesia, focusing on ICT infrastructure, perceived security, perceived risk, and digital literacy. A survey of 135 young adults was conducted online, with data analysed using SPSS. Findings indicate that ICT infrastructure and digital literacy significantly impacted digital economy sustainability. These insights are crucial for policymakers and stakeholders aiming for inclusive digital economic development.

Keywords: Electric Commerce; Digital Economy; Sustainable Digital Economy; Information Communication Technology (ICT) Infrastructure

DOI: https://doi.org/10.21834/e-bpj.v10i31.6400

1.0 Introduction

The rapid growth of information and communication technology (ICT) has revolutionised the digital landscape, transforming global business operations through e-commerce worldwide since 1990 (Farliana et al., 2024). They have also reported that Indonesia has been among the active Southeast Asian countries (SEA) trying to initiate digital transformation measures to boost economic growth. With the rapid rise of digital interaction in Indonesia, it is essential to comprehend the nuance of e-commerce practice in the country, where online shopping is gaining popularity (Muhammad & Muhammad, 2024). This is because the e-commerce sector creates business, efficiency, and profitability advantages and helps reshape consumer interactions with brands. In Indonesia, platforms like Tokopedia, Shopee, and Lazada have driven e-commerce growth among the users, supporting micro, small, and medium enterprises (MSMEs) and contributing to the nation's digital economy, which accounted for 7% of its GDP in 2022 and represents 40% of ASEAN's digital economy (Masduki, 2023). This figure further substantiates that the digital economy has significantly contributed to Indonesia's economic growth. The e-commerce market value of US$ 43 billion and significant gross merchandise value (GMV) recorded by the Indonesian market have further made ways for Indonesia to be known as a leader in global and ASEAN e-commerce (Tay & Wintels, 2023). Therefore, choosing Indonesia as a study area will further reflect the current scenario of the digital economy. However, challenges

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DOI: https://doi.org/10.21834/e-bpj.v10i31.6400

like the digital divide have always hindered the sustainable growth of digital businesses and led to a failure to achieve desired performance outcomes (Ma,2023).

Thus, this study intends to investigate the key factors influencing the development of a sustainable digital economy in Indonesia and develop a solution model to stimulate and maintain sustainable digital economy business operation. Specifically, the study seeks to achieve four main objectives: (1) to analyse the relationship between ICT infrastructure development and the sustainability of the digital economy; (2) to evaluate the impact of perceived security on the digital economy, particularly among e-commerce users; (3) to assess the effect of perceived risk on the sustainability of the digital economy; and (4) to explore the effect of digital literacy in promoting a sustainable digital economy among e-commerce users in Indonesia. Through these objectives, the study aims to provide valuable insights into the drivers and challenges of building a resilient and sustainable digital economy in the country using a regression model analysis.

1.1 Problem Statement

The failure to implement effective digital economy strategies has contributed significantly to the closure of many businesses in Indonesia, particularly among Micro, Small, and Medium Enterprises (MSMEs) (Ma,2023). Despite the growing importance of digital transformation, many MSMEs have needed help to adapt to the digital landscape, resulting in severe operational challenges and business shutdowns (Ma, 2023). Although the pandemic accelerated the need for digital engagement, MSMEs, which form the backbone of Indonesia's economy, faced difficulties in adopting digital tools such as digital marketing and e-commerce, leading to a decline in sales and market reach (Ma, 2023). He also stated that failure to understand the contributing factors to a sustainable digital economy worsened the problem.

Despite government initiatives and resources aimed at fostering digital skills, many MSMEs remain ill-equipped to harness the potential of the digital economy (Aminullah et al., 2021). Furthermore, infrastructure challenges, including slow internet speeds and limited coverage in rural areas, exacerbate the difficulties faced by businesses in remote regions. In Indonesia, slow internet speeds rank 120th globally, and 26.3% of rural populations lack internet access, which affects over 12,500 villages and 104,000 schools (Aminullah et al., 2021)

Additionally, the rapid growth of e-commerce has introduced new vulnerabilities, including increased risks of cyber-attacks and data breaches, further discouraging businesses from fully embracing digital transformation. Cyber-attacks in Indonesia surged from 99.8 million cases in 2019 to 621 million in 2021, with high-profile incidents like data leaks at Tokopedia and Bukalapak (Mulya et al., 2021). These security concerns and low digital literacy among the Indonesian population contribute to the significant challenges in maintaining sustainable digital businesses. A study by Ramdhani et al. (2021) highlights that Indonesia's digital literacy index still needs to be higher, recorded at just 3.54, with only 7.4% of MSMEs using digital platforms for online transactions.

These issues underscore the urgent need for a more comprehensive and accessible digital strategy to ensure the sustainability and growth of MSMEs in Indonesia. Without proper support in digital literacy, infrastructure, and security, many businesses will continue to face insurmountable challenges, leading to closures and exacerbating economic disparities across the country (Melinda et al., 2023). The problem lies in the need for adoption and the broader context of digital readiness and resilience, which is essential for businesses to thrive in an increasingly digital world.

2.0 Literature Review

Previous research (Sutono et al., 2023) tend to isolate the variables meaning that the research only focuses on analyzing the relationship between one of the four key factors towards the dependent variable. Furthermore, previous research centers on understanding the aspect that affects the present digital economic growth and overlooks the long-term growth. This research addresses the knowledge gap by incorporating all the four key factors into the model to better understand the relationship of those factors towards a long-term sustainable growth of the digital economy.

2.1 ICT Infrastructure and Sustainable Digital Economy

Economic sustainability focuses on long-term stability (Mahmoud et al., 2023). They also agreed that a sustainable digital economy refers to various economic activities that depend on information technology and knowledge.

Therefore, this study intends to investigate the relationship between the independent factors that affect the sustainability of the e-commerce business. The first factor involved is ICT infrastructure, which shows that innovations and advancements have significantly influenced the development of e-commerce in ICT (Farhad et al., 2023). This indicates that technological progress plays a crucial role in shaping the e-commerce landscape in the country. Apart from that, they have also agreed that ICT infrastructure is crucial in stimulating digital economy growth. Thus, the following hypothesis was proposed:

H_1: The sustainability of Indonesia's digital economy is directly linked to the quality of ICT infrastructure available to e-commerce users in the region.

2.2 Perceived Security and Sustainable Digital Economy

Perceived security refers to a customer's belief that their private information is protected during online transactions, with confidence that unauthorised parties cannot steal their data (Kalinin et al., 2024). It is also defined as the customer's level of control over their sensitive information within an online system and their judgment on the safety of a platform (Kalinin et al., 2024). They also perceive that security

reflects the user's trust in the security of personal credentials during transmission on an online platform. Thus, the following hypothesis was proposed:

H_2: The sustainability digital economy is directly linked to the quality of security provided to e-commerce users in the region.

2.3 Perceived Risk and a Sustainable Digital Economy

Perceived risk is the potential dissatisfaction arising from an online purchase, which occurs when a buyer's expectations of the product or service are unmet (Deb et al.,2024). Apart from that is agreed by the majority of the previous study that a primary concern for consumers is the financial losses associated with online transactions, which is linked to the perceived risk (Garba et al., 2024). Thus, the following hypothesis was proposed:

H_3: The sustainability digital economy is directly linked to the level of perceived risk indicated by the e-commerce users in the region.

2.4 Digital Literacy and a Sustainable Digital Economy

Digital literacy refers to understanding computer hardware and software, online safety, data analysis, and the technological skills necessary to operate digital tools and platforms (Intaratat, 2022). It encompasses four key components: technological skills, information processing, communication, and creation. A study indicates that internet literacy positively contributes to economic growth and enhances education and health outcomes (Ramdhani et al.,2021). Thus, the following hypothesis was proposed:

H_4: The sustainability of Indonesia's digital economy is directly linked to the quality of digital literacy among e-commerce users in the region.

Fig 1 illustrates the research framework for the study, with four main hypotheses being proposed.

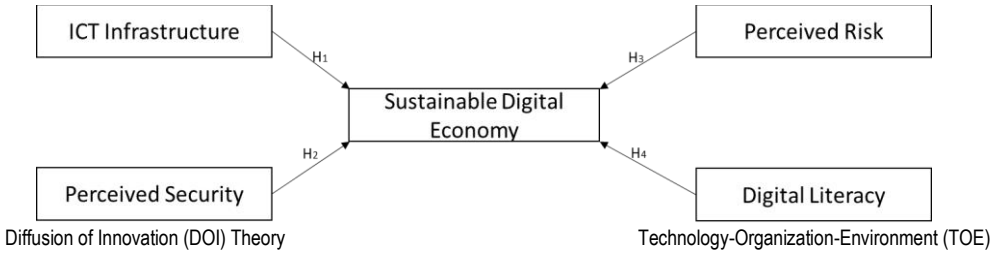

Fig 1: Research Framework

The Technology-Organization-Environment (TOE) Framework and Diffusion of Innovation (DOI) Theory provide valuable theoretical foundations for understanding the relationships in the research framework of ICT Infrastructure, Perceived Security, Perceived Risk, Digital Literacy, and a Sustainable Digital Economy. The Technology-Organization-Environment (TOE) (Farliana,2024). Framework and Diffusion of Innovation (DOI) Theory (Subagja, 2023). provide complementary perspectives for understanding the factors influencing a sustainable digital economy in Indonesia. The TOE framework emphasises the role of ICT infrastructure, perceived security, and digital literacy as technological and organisational factors affecting e-commerce sustainability among users, while perceived risk is considered an environmental factor. DOI theory focuses on how innovations, such as ICT infrastructure and digital security, are adopted and diffused within society, highlighting the importance of relative advantage, compatibility, and user skills in accelerating adoption. Both theories underscore the importance of infrastructure, security, and digital literacy in fostering a sustainable digital economy.

3.0 Methodology

This study used simple random sampling since it enables researchers to conclude a larger population. It chooses random participants from the population, giving everyone an equal chance of being selected (Saunders et al., 2012). A similar study conducted by Kang (2021) also calculates their sample size using G-Power software, as this method creates some flexibility for various research methods. The sample size suggested through the G-Power platform was 135 participants living in Indonesia's urban areas (Ali et al.2024) with prior experience in e-commerce purchases (Najah,2024). The urban areas chosen are vital urban cities in major islands of Indonesia, such as Java, Bali, Kalimantan, and Sumatra. These areas were chosen because they are the epicentre of digital connectivity, which is suitable for showing the most relevant results for the study (Aminullah et al,2022). Nevertheless, this study excludes rural residents in Indonesia. A set of questionnaires was developed using the five-point Likert scale (Tanujaya et al., 2023) to collect the data. The research employs a cross-sectional method where data was collected over 3 weeks using an online platform (Svetlana, 2022) approach for the respondents selected. The link to the survey was distributed among the residential community in Indonesia using various online platforms. Four leading platforms were used to blast the link, including Facebook, Instagram, Telegram, and WhatsApp groups, with a return of 170 responses gathered. However, only 135 responses were valid and used for the analysis, recording 79% validity of the answers collected. A filtering question was designed to filter the criteria of the selected respondents in this study to avoid invalid responses. This includes questions such as the area of their residential area and e-commerce experience. The data was then analysed using SPSS (Svetlana, 2022), with a desriptive analysis, Cronbach's Alpha test, and Multiple Regression Analysis.

4.0 Findings

4.1 Descriptive Analysis

The study starts by analysing the demographic characteristics of the respondents, which are presented in Table 1. It is clear from Table 1 that males reflect more on e-commerce purchases than females, with the most active users being 21-23 years old. The two most important questions asked to filter the respondents were stated clearly in the residential area where only those residing in urban areas were considered, whereas the rural area population was excluded. It is the same with the e-commerce experience, where only those with e-commerce experience were considered samples in this study.

Table 1: Demographic Analysis

Demographic Info	Types	Frequency	Per cent
Gender	Male	95	24
	Female	40	59
Age	18-20 Years Old	24	17.8
	21-23 Years Old	59	43.7
	24-27 Years Old	29	21.5
	28-30 Years Old	23	17.0
Residential Area	Urban	135	100
	Rural	0	0
E-Commerce Experience	Yes	135	100
	No	0	0

Cronbach's Alpha was used to test the questionnaire's validity. Table 2 indicates the score for each construct. In this case, every variable has a perfect reliability score above 0.8 for all independent and dependent variables tested in the study (Saunders, 2012).

Table 2: Cronbach's Alpha Value

Variables	**Cronbach's Alpha Score**
ICT Infrastructure – IV	0.899
Perceived Security – IV	0.895
Perceived Risk – IV	0.862
Digital Literacy – IV	0.893
Sustainable Digital Economy – DV	0.879

Regression analysis was conducted to test the relationship between the independent and dependent variables using a coefficient in regression analysis. Table 3 indicates the result. It shows that the independent variable affected only 59% of the dependent variable. The R Square value further indicates that the predictors in the model explain approximately 35.1% of the variation in the dependent variable. The R Square is low due to the nature of social science studies focusing on human behavior that constantly changes. There are many external factors that make it difficult to predict human behavior. Even if the model included all of the external variables, the variables may weaken the relationship with the dependent variable resulting in a lower R-Square (Ozili, 2022).

Table 3: Model Summary of Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.592[a]	0.351	0.331	0.52270

a. Predictors: (Constant), AVG_DL, AVG_PS, AVG_II, AVG_PR

Table 4: Coefficients in Regression Analysis

		Unstandardised Coefficients		Standardised Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.209	0.291		4.158	<0.001
	ICT Infra	0.185	0.083	0.213	2.230	0.027
	P.Security	0.207	0.084	0.234	2.469	0.015
	P.Risk	0.069	0.098	0.074	0.709	0.480
	Digital. L	0.174	0.086	0.195	2.035	0.044

a. Dependent Variable: Sustainable Digital Economy

The multiple regression analysis reveals that ICT Infra, Perceived Security, and Digital Literacy are statistically significant predictors of the "Sustainable Digital Economy," with p-values less than 0.05, indicating that increases in these variables are associated with

improvements in the dependent variable. Precisely, ICT Infra (β = 0.213), Perceived Security (β = 0.234), and Digital. L (β = 0.195) all have positive relationships with the outcome, with Perceived Security showing the most substantial impact. However, Perceived Risk (β = 0.074) is not a significant predictor (p = 0.480), suggesting it does not meaningfully contribute to the model. The intercept is also statistically significant (p < 0.001), indicating the baseline value of the Sustainable Digital Economy when all predictors are zero. Overall, the results highlight the importance of ICT infrastructure, privacy/security, and digital literacy in fostering a sustainable digital economy.

Table 5:ANOVA Analysis

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.197	4	4.799	17.566	<0.001[b]
	Residual	35.518	130	0.273		
	Total	54.715	134			

a. Dependent Variable: SDE
b. Predictors: (Constant), DL, PS, ICT, PR

The results of the ANOVA test for the regression model show a significant overall fit. The model's regression sum of squares is 19.197, with 4 degrees of freedom, and the mean square for regression is 4.799. The F-statistic is 17.566, with a p-value less than 0.001, indicating that the regression model as a whole is statistically significant in predicting the dependent variable (AVG_SDE). The residual sum of squares is 35.518 with 130 degrees of freedom, resulting in a mean square for the residuals of 0.273. The total sum of squares is 54.715 with 134 degrees of freedom. This suggests that the predictors (DL, PS, ICT, PR) significantly explain the variation in the dependent variable (Sustainable Digital Economy).

4.2 Multiple Regression Equation

The multiple regression equation for predicting the "Sustainable Digital Economy" (γ) is as follows:

$$\gamma = \alpha + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + \varepsilon \quad (1)$$

γ=1.209+0.185×(ICT Infrastructure)+0.207×(Perceived Security)+0.069×(Perceived Risk)+0.174×(Digital Literacy)+0.291

The equation's constant (α=1.209) represents the baseline Sustainable Digital Economy value. Positive coefficients for ICT Infrastructure (B_1=0.185), Perceived Security (B_2=0.207), and Digital Literacy (B_4=0.174) indicate their strong influence, while Perceived Risk (B_3=0.069) shows a weak, non-significant effect. The error term (ε) captures unexplained variation. This model can assess the variance in the relationship between the dependent variable and the independent variable by using a simulation score ranging from 1 (very dissatisfied) to 5 (very satisfied) to report on the sustainability of the digital economy model.

The hypothesis testing revealed that three out of four hypotheses were supported. H_1 significantly linked Indonesia's digital economy sustainability to ICT infrastructure quality (p=0.027). H_2, connecting sustainability to e-commerce security quality, was also significant (p=0.015). H_4, associating sustainability with digital literacy among users, showed significance (p=0.044). However, H_3, proposing a link between sustainability and perceived risk, was rejected (p=0.480). This suggests that perceived risk may not be a priority for Indonesian e-commerce users, who likely value ICT infrastructure, security, and literacy more. Additionally, the sample size or growing user familiarity with online transactions may have influenced the result.

5.0 Discussion

The first hypothesis, which proposed a significant positive relationship between ICT infrastructure and a sustainable digital economy, was confirmed (correlation = 0.492, p = 0.027). This finding is consistent with prior research, such as Mahmoud et al. (2023) and Farhad (2023), which highlighted the vital role of robust ICT infrastructure in facilitating economic growth and digital transformation. As Indonesia continues to build its digital economy, developing ICT infrastructure remains fundamental in ensuring access to digital platforms, enabling businesses and consumers to participate in e-commerce and other online activities.

The second hypothesis, which suggested that perceived security positively affects a sustainable digital economy, was also supported (correlation = 0.498, p = 0.015). This result aligns with the work of Undale et al. (2022) and Kalinin et al. (2024), emphasising the importance of security in fostering trust in e-commerce. The positive relationship between perceived security and a sustainable digital economy underscores the need for ongoing investments in cybersecurity, which can mitigate risks associated with online fraud and data breaches, ultimately promoting long-term growth in Indonesia's digital economy.

Contrary to expectations, the third hypothesis, which proposed a significant relationship between perceived risk and sustainability, was not supported (correlation = 0.467, p = 0.480). This finding contradicts studies by Garba et al. (2024) and Deb et al. (2024), who found that perceived risk significantly influences online shopping behaviour. This result suggests that while perceived risks, such as concerns about fraud or delivery issues, are important to consider, they may not be as influential in shaping the overall sustainability of Indonesia's digital economy. One possible explanation is that consumers may have become more accustomed to the digital environment, leading to a decrease in their perceived risk.

The final hypothesis, which suggested that digital literacy positively impacts a sustainable digital economy, was confirmed (correlation = 0.488, p = 0.044). This finding aligns with research by Intaratat (2022) and Ramdhani et al. (2021), which underscores the importance of digital literacy in fostering e-commerce adoption and contributing to economic growth. In Indonesia, where digital adoption

is rapidly increasing, enhancing digital literacy at all levels of society is crucial. By promoting digital literacy, Indonesia can foster a more inclusive and sustainable digital economy that benefits all segments of society. In terms of the theoretical implications, the findings may give new insights that can contribute to the body of knowledge. The findings support The TOE framework emphasises the influence of technological, organisational, and environmental factors on e-commerce sustainability, particularly in the context of perceived risk and digital literacy. Meanwhile, DOI theory underscores the importance of innovation adoption and diffusion processes in terms of ICT infrastructure and security, focusing on the importance of relative advantage, compatibility, and user skills in e-commerce adoption. Together, these theories demonstrate that strengthening ICT infrastructure, ensuring digital security, and enhancing digital literacy are essential for building a resilient and inclusive digital ecosystem that drives economic growth.

The practical implications of these findings can be used by government bodies to improve and develop ICT infrastructure in Indonesia, as well as initiating digital literacy programs for the education system. Furthermore, the findings inform e-commerce companies to enhance and implement advance security measures that protects customer's private information, while also educating employees with valuable digital skills that are necessary in today's workforce. Finally, these findings can assist people to always stay vigilant and safe while conducting e-commerce purchase and remind people to always stay up to date with the current digital skills and knowledge.

6.0 Conclusion& Recommendations

In conclusion, this study underscores the crucial role of ICT infrastructure, digital security, and digital literacy in fostering a sustainable digital economy in Indonesia, based on the Technology-Organization-Environment (TOE) Framework and Diffusion of Innovation (DOI) Theory. The result of this research highlights that ICT infrastructure, perceived security, and digital literacy are key factors in creating a sustainable digital economy, while perceived risk is not as impactful as the other factors. The limitation of the research was its focus on respondents from urban areas, excluding rural populations. Furthermore, the respondents chosen are from the age of 18-30 years old and have prior experience in e-commerce purchase, which may affect the generalizability of the findings. Retrospectively, the research highlights the importance of both government and industry stakeholders in building a secure, accessible, and educated digital ecosystem, which is essential for a successful and sustainable digital economy. Recommendations for improving the current situation are creating a well-developed ICT infrastructure, enhancing e-commerce security measures, and including digital skills and knowledge into the curriculum, these are key elements in creating long-term digital economic sustainability. Future research should explore regional differences in ICT infrastructure and highlight a specific city to ensure accuracy, employ mixed research methods to deepen the understanding of perceived security since different people may have different perceptions of security, focus on a specific risk associated with e-commerce rather because different types of risks may have varied results, and consider external factors of digital literacy, such as demographic and socioeconomic factors that may affect people's perspective towards digital literacy.

Acknowledgements

Thanks to the Asia Pacific University of Technology and Innovation for the resources throughout the study and to AMER for the research funding.

Paper Contribution to Related Field of Study

This research contributes to understanding the factors influencing the sustainability of Indonesia's digital economy by empirically examining the roles of ICT infrastructure, perceived security, perceived risk, and digital literacy. It highlights the critical importance of ICT infrastructure, security measures, and digital literacy in promoting e-commerce growth and sustainability. It provides insights for policymakers to prioritise infrastructure investments and security enhancements. The study also underscores the minimal impact of perceived risk, suggesting a shift in user concerns, and recommends nuanced approaches to improve digital literacy and address regional disparities. These findings offer a foundation for future studies to refine strategies for sustainable digital economies.

This research makes both theoretical and practical contributions. Theoretically, it extends the Technology-Organization-Environment (TOE) Framework and Diffusion of Innovation (DOI) Theory by empirically validating the roles of ICT infrastructure, perceived security, digital literacy, and perceived risk in the sustainability of Indonesia's digital economy. The findings refine these frameworks, demonstrating how technological and environmental factors influence e-commerce sustainability. Practically, the study offers valuable insights for policymakers, such as the Ministry of Education, so that digital literacy can be included in the curriculum. Additionally, this study can also provide important information for stakeholders, such as telecom companies to improve ICT infrastructure and e-commerce platforms to enhance its security measures. This study emphasizes the need for investments in ICT infrastructure, enhanced digital security, and digital literacy to foster a more sustainable and inclusive digital economy, providing actionable strategies for improving e-commerce engagement and trust.

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