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Sustainable Digital Banking Adoption: Extending the Technology Acceptance Model with Trust, Risk, and ESG Factors

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Abstract

This study investigates the adoption of online banking in Taiwan by extending the Technology Acceptance Model (TAM) to incorporate trust, perceived risk, and environmental, social, and governance (ESG) factors. Drawing on survey data from 250 respondents and employing Structural Equation Modeling (SEM), the research confirms that perceived usefulness and ease of use remain critical determinants of behavioral intention. Trust emerged as a vital mediator, while perceived risk negatively influenced adoption. Importantly, the findings reveal that both perceived ESG and behavioral ESG practices significantly shape customer trust, behavioral intention, and actual system use, underscoring the growing role of sustainability in digital finance. The results highlight a reciprocal relationship between perceived and behavioral ESG, where customer perceptions incentivize banks to implement substantive ESG actions. The study contributes theoretically by integrating TAM with sustainability perspectives and offers practical insights for banks and policymakers to promote secure, inclusive, and sustainable digital banking.

JEL classification numbers: G21, O33, Q56.
Keywords: Online Banking Adoption, Technology Acceptance Model, Trust, Perceived Risk, ESG.

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1. Introduction

In the contemporary business environment, the strategic use of web-based technologies has become indispensable for enhancing organizational competitiveness and ensuring long-term sustainability. Within the financial services sector, banks, in particular, are compelled to continually expand and diversify their range of digital services to retain customers and meet evolving consumer expectations. Nevertheless, the effective development of such strategies remains challenging. Many financial institutions are under pressure to devise approaches that simultaneously minimize operational costs, ensure accessibility to a broad demographic base, and reduce the time required for service delivery. These imperatives have become even more pronounced in the aftermath of the COVID-19 pandemic, which significantly disrupted traditional banking practices and accelerated the shift toward contactless and digital financial solutions. In Taiwan, where digital banking and mobile payment infrastructures were already well established, the COVID-19 pandemic further accelerated the adoption of cashless services. The increasing popularity of mobile wallets and the launch of virtual banks have reshaped consumer expectations, emphasizing not only convenience but also the integration of sustainability and ESG-driven practices within the financial sector (Tanwar and Verma, 2024).

In parallel, environmental, social, and governance (ESG) considerations have gained prominence in Taiwan's financial sector, where banks are increasingly expected to align their operations with sustainability goals to enhance competitiveness, manage long-term risks, and strengthen institutional resilience. ESG integration is no longer viewed as peripheral but as a core component of sustainable banking practices. Alamsyah and Muljo (2023) conducted a study examining the effects of Environmental, Social, and Governance (ESG) factors on banking performance in the Asia-Pacific region, including Taiwan. Their findings revealed that while ESG indices did not significantly influence Return on Assets (ROA), they positively impacted Return on Equity (ROE). This suggests that adopting ESG-oriented strategies can enhance bank profitability in the region. The development of financial technologies has further accelerated this transformation, enabling banks to pursue digital innovations that complement their ESG objectives, such as paperless transactions, reducing carbon footprints, and providing inclusive financial services. Empirical studies suggest that ESG-driven strategies can shape bank profitability, reputation, and stability, and the experience of the COVID-19 pandemic has reinforced their importance in building resilient financial systems (Chang et al., 2021).

From an operational standpoint, information technology (IT) has revolutionized financial services in Taiwan, enhancing both efficiency and service quality. Online and mobile banking platforms have become the dominant channels through which customers conduct transactions and manage accounts. Unlike India, where economic liberalization in the 1990s triggered large-scale internet banking adoption, Taiwan's banking sector already entered the digital era with a robust IT infrastructure, strong smartphone penetration, and high consumer digital literacy. This foundation allowed Taiwanese banks to rapidly expand digital offerings, integrating traditional banking functions with internet and mobile technologies to

improve accessibility and customer experience. Empirical analysis further supports this transformation, Liao (2023) finds that Fintech-related initiatives, including mobile payment systems, contribute positively to bank efficiency in Taiwan.

Nevertheless, challenges remain. Concerns over cybersecurity, data privacy, and the operational resilience of digital platforms represent ongoing risks for financial institutions and regulators. Moreover, despite Taiwan's advanced digital ecosystem, certain populations - such as the elderly or residents in rural regions - still face barriers in fully adopting mobile and online banking solutions. In response, the Financial Supervisory Commission (FSC) has actively promoted digital financial inclusion from the Report of Banking Bureau, FSC (2023), supporting the launch of virtual banks - such as Rakuten Bank, LINE Bank, and Next Bank - while encouraging traditional banks to expand ESG-oriented digital services. Since April 2018, the Financial Supervisory Commission (FSC) has officially allowed the establishment of internet-only banks. By the end of 2021, operating licenses had been granted to Rakuten International Commercial Bank, LINE Bank Taiwan, and Next Bank, reflecting policy initiatives aimed at advancing financial inclusion through digital innovation. Additionally, the FSC continues to enhance accessibility for disadvantaged groups and people with disabilities by mandating accessible online banking services, expanding visually impaired-friendly ATMs, and promoting digital financial literacy campaigns in remote and rural areas.

The importance of digital banking was underscored during the COVID-19 crisis, when uninterrupted access to financial services became vital for households and businesses. Taiwanese banks responded by accelerating the deployment of mobile payment systems (e.g., LINE Pay, JKoPay) and enhancing online banking functions. These innovations not only sustained financial activity during the pandemic but also advanced the government's broader goal of fostering a cashless society. Taiwan′s mobile payment penetration is projected to approach 90% by 2025, highlighting rapid adoption in response to both consumer demand and institutional Fintech expansion. According to FSC data, Taiwan's electronic payment transaction volume exceeded TWD 1 trillion in 2022, reflecting robust growth in consumer adoption and institutional investment in Fintech.

As digital transactions continue to expand, Taiwanese banks are increasingly leveraging Fintech to integrate ESG principles into their business models - ranging from energy-efficient data centers to green financing initiatives. The pandemic catalyzed this digital-ESG convergence, embedding sustainable digital banking practices into both institutional strategies and consumer behavior. Yuan (2025) demonstrates that Fintech adoption positively influences both environmental performance and financial performance in banking institutions, underscoring the strategic value of ESG-aligned digital innovations. In the post-pandemic era, online banking in Taiwan has evolved beyond mere convenience to become a strategic tool for sustainable competitiveness and reinforcing customer trust.

2. Literature Review

2.1 Extended Technology Acceptance Model

The Technology Acceptance Model (TAM), originally proposed by Davis (1989) and grounded in the Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen in 1975 (Rutter and Bunce, 1989), is one of the most widely applied theoretical frameworks for examining user acceptance and adoption of technology. TAM adapts behavioral intention theories to the specific context of technology use, offering a parsimonious yet powerful explanation of how individuals evaluate and decide to employ technological systems. The model posits five core constructs that capture the determinants of technology adoption. Perceived Usefulness (PU) refers to the extent to which individuals believe that using a given technology will enhance their performance or effectiveness, such as reducing transaction errors or improving efficiency in financial service delivery. Perceived Ease of Use (PEOU) is defined as the degree to which individuals believe that a technology can be utilized with minimal effort, for instance, when mobile banking applications provide clear interfaces and intuitive navigation. Collectively, PU and PEOU shape the user's Attitude toward Use (ATT), which reflects the overall affective evaluation of the technology. A favorable attitude, reinforced by perceptions of usefulness, directly influences Behavioral Intention to Use (BI), the most immediate predictor of actual adoption. Finally, Actual System Use (AU) denotes the realized engagement with the technology, which may be reflected in the frequency of online banking logins, the number of transactions performed, or the extent of system utilization. In this way, TAM provides a theoretically grounded and empirically validated framework for analyzing the cognitive and affective processes underpinning technology adoption, and it remains a cornerstone in information systems and digital banking research.

Over time, TAM has undergone significant refinement and extension to account for a broader set of determinants influencing technology adoption. TAM2 expanded the original framework by integrating *social influence mechanisms* - such as subjective norms and image - with *cognitive instrumental processes,* including job relevance, output quality, and result demonstrability (Bertrand and Bouchard, 2008). This extension recognized that both social pressures and task-related considerations critically shape users' perceptions of usefulness and their subsequent intentions to adopt technology. TAM3 further advanced the model by elucidating the antecedents of perceived ease of use, incorporating factors such as computer self-efficacy, perceptions of external control, computer anxiety, and playfulness (Venkatesh and Bala, 2008). These additions underscored the significance of individual differences and contextual enablers in shaping technology adoption behaviors. Building on these foundations, the Unified Theory of Acceptance and Use of Technology (UTAUT) proposed by Venkatesh et al. (2003) synthesized TAM with multiple acceptance theories to construct a more integrative framework. UTAUT highlights constructs such as performance expectancy, effort expectancy, social influence, and facilitating conditions as central predictors of behavioral intention and actual usage. Collectively, these theoretical advancements reflect an evolution from a relatively

narrow explanatory model to a more comprehensive framework, capturing the interplay of social, cognitive, and contextual dynamics that govern technology acceptance and use.

The Extended Technology Acceptance Model (TAM) builds upon the original framework by incorporating additional constructs that are either theoretically grounded, such as TAM2, TAM3, and the Unified Theory of Acceptance and Use of Technology (UTAUT), or specific to the research context. In the area of online banking adoption, the Extended TAM may include various dimensions, such as Perceived Usefulness (PU), which relates to improved efficiency and faster transaction processes, and Perceived Ease of Use (PEOU), which refers to the user-friendliness of mobile applications or websites.

Moreover, the extended model incorporates Trust, which reflects users' confidence in the security of online transactions, the robustness of data protection practices, and the overall reliability of financial institutions. It also integrates Perceived Risk, capturing users' concerns regarding potential fraud, privacy breaches, and other vulnerabilities associated with digital banking. In addition, the construct of Post-Environmental Sustainability Goal Behavior accounts for customers' evaluations of a bank's commitment to environmental and social responsibility, thereby aligning technology adoption with broader sustainability expectations. By incorporating these dimensions, the model advances beyond purely functional determinants of adoption to encompass ethical, psychological, and social factors that significantly influence user decision-making. This comprehensive perspective offers a more nuanced understanding of online banking adoption, particularly in contexts where trust, risk perception, and sustainability considerations are key factors. Accordingly, and based on the literature review, we propose the conceptual research framework depicted in *Figure 1*.

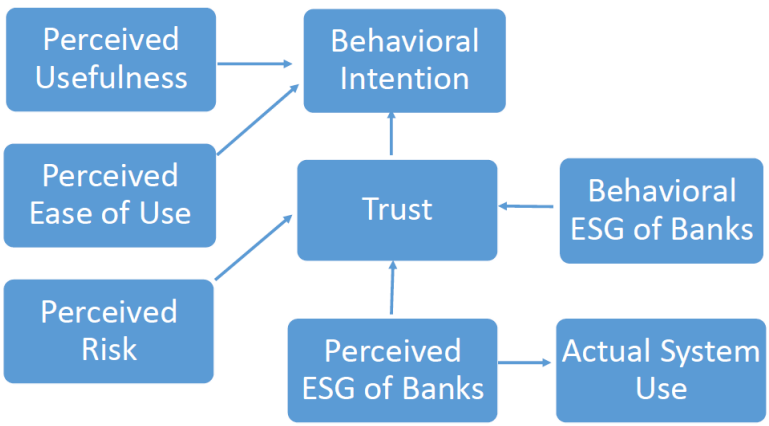

Figure 1: The Conceptual Research Framework

2.2 Perceived Usefulness and Behavioral Intention

In the context of online banking adoption, Perceived Usefulness (PU) is considered one of the strongest determinants of Behavioral Intention (BI) to use digital banking services. PU reflects the extent to which customers believe that using online banking will enhance their financial management efficiency, save time, and improve convenience. According to Davis's Technology Acceptance Model (TAM), users are more likely to form a positive intention toward adopting technology when they perceive it as beneficial for achieving their goals (Davis, 1989).

Empirical studies have consistently reinforced this relationship in online banking contexts. For example, Pikkarainen et al. (2004) found that customers' perceptions of online banking usefulness - such as reduced transaction costs, flexibility, and accessibility - significantly increased their likelihood of adoption. Similarly, Martins, Oliveira, and Popovič (2014) reported that perceived usefulness strongly predicted customers' intention to adopt internet banking in Europe, even more than ease of use. Moreover, Rahi, Ghani, and Alnaser (2017) emphasized that usefulness perceptions play a crucial role in shaping trust, which in turn strengthens behavioral intentions.

In practice, customers who believe that online banking provides tangible advantages - such as 24/7 access, faster fund transfers, or simplified bill payments - are more motivated to use and continue using these services. The emphasis on usefulness is particularly relevant in emerging economies, where digital adoption often competes with entrenched habits of cash-based transactions. Enhancing the usefulness of digital services through innovation and user-friendly features is a critical strategy for banks to influence customer behavior. We propose,

H1: Perceived Usefulness (PU) has a positive and significant effect on Behavioral Intention (BI) to adopt online banking.

2.3 Perceived Ease of Use and Behavioral Intention

Perceived Ease of Use (PEOU) - defined as the belief that utilizing an online banking platform necessitates minimal effort - emerges as a crucial determinant of Behavioral Intention (BI) to adopt such services. A quantitative investigation conducted by Putri and Tan (2025) among mobile banking users of BRI Bank in Kendari City, employing SmartPLS analysis, demonstrated that PEOU, along with Perceived Usefulness and Trust, exerts a significant positive influence on BI regarding mobile banking adoption. Furthermore, Widiar, Yuniarinto, and Yulianti (2023) examined the role of PEOU in affecting BI, both directly and indirectly through mediation by Perceived Usefulness and Trust, in the context of Indonesian mobile banking users. Their findings affirm that enhancements in both PEOU and the aforementioned mediators lead to a stronger inclination toward adoption.

In parallel, Mekić et al. (2025) investigated the usage of online banking in Bosnia and Herzegovina, uncovering that PEOU significantly influences Perceived Usefulness, with both constructs - PEOU and Perceived Usefulness - serving as

essential predictors of BI. Collectively, these studies illuminate a dual dynamic: (1) PEOU can directly elevate BI, particularly when coupled with perceptions of system usefulness and trust; and (2) PEOU can indirectly affect BI by bolstering Perceived Usefulness and, in some instances, Trust. This complex interplay underscores the necessity for online banking platforms to deliver intuitive and seamless user experiences that not only exude ease of use but also manifest tangible benefits for users, thereby encouraging adoption intentions. Therefore, we posit,

H2: Perceived Ease of Use (PEOU) has a positive and significant direct effect on Behavioral Intention (BI) to adopt online banking.

2.4 Perceived Risk and Trust

In the online banking adoption literature, Perceived Risk - defined as the customer's expectation of potential loss in using a digital financial service - remains a central barrier to acceptance. Risks may include financial fraud, data privacy breaches, transaction errors, or system unreliability. High perceived risk often erodes Trust, which is essential for users' willingness to engage with online banking platforms.
Recent empirical studies provide evidence for this relationship. Alalwan et al. (2018) highlighted that when customers perceive high risks in online transactions, their trust in mobile banking services decreases, ultimately weakening adoption intention. Similarly, Martins, Oliveira, and Popovič (2014) found that perceived risk negatively influences trust, which serves as a mediating factor for behavioral intention in Internet banking. More recently, Rahi, Ghani, and Alnaser (2017) confirmed that risk perceptions directly hinder trust formation, while trust positively enhances user satisfaction and adoption in online financial services.
The interaction between perceived risk and trust is therefore inverse and dynamic: the higher the risk, the weaker the trust; conversely, when risks are managed through security assurance, transparent policies, and reliable service quality, trust is strengthened, encouraging adoption. This highlights the strategic role of banks in reducing risk perceptions by implementing strong authentication systems, data protection measures, and consistent service reliability. Overall, the literature suggests that addressing perceived risks is a prerequisite for establishing trust, which in turn is a decisive factor in determining users' behavioral intention to adopt online banking.

H3: Perceived Risk (PR) hurts Trust in the context of online banking adoption.

2.5 Behavioral Intention and Behavioral ESG of Banks

In recent years, Environmental, Social, and Governance (ESG) performance has emerged as a crucial factor shaping customer perceptions of banks. Beyond traditional financial criteria, customers increasingly evaluate banks based on their behavioral ESG practices - how effectively banks embed sustainability, ethical responsibility, and transparency into their daily operations. In the digital banking

context, Behavioral Intention (BI) to adopt online services is significantly influenced by how customers perceive and interpret these ESG behaviors.
Liang et al. (2018) suggest that ESG engagement fosters greater customer trust and loyalty. Banks with stronger ESG performance enjoy higher reputational capital, which translates into greater customer acceptance of their financial services. Similarly, Broadstock et al. (2021) highlighted that ESG-driven communication positively moderates consumer attitudes, thereby enhancing BI in financial decision-making. More recently, Belova et al. (2023) emphasized that customers interpret sustainable banking practices as signals of reliability and long-term stability, which increases their willingness to adopt online banking platforms.
The theoretical underpinning lies in ethical consumer behavior and the extended TAM framework. When banks demonstrate ESG commitment - through reducing paper use, supporting green finance, or adopting socially responsible lending practices - customers not only perceive online banking as useful and convenient but also align their BI with values of sustainability and ethical responsibility. In this sense, Behavioral ESG of Banks (BESGB) functions as both a reputation enhancer and a motivational driver for adoption. Accordingly, we present,

H4: The relationship between Behavioral ESG of Banks (BESGB) and Behavioral Intention **(**BI) is mediated by Trust - strong ESG practices enhance trust, which in turn strengthens BI.

2.6 Perceived ESG of Banks and Behavioral ESG of Banks

The Perceived ESG of Banks refers to how consumers - or stakeholders more broadly - recognize and interpret a bank's commitments to environmental, social, and governance (ESG) principles. This perception can be shaped by branding, ESG disclosures, sustainability reports, and public reputation. Research demonstrates that higher perceived ESG enhances customer trust, satisfaction, and loyalty. For instance, content highlighting ESG dimensions improves behavioral outcomes such as purchase intention and brand trust, driven by perceived ethicality and authenticity (Korzeb et al., 2024).
By contrast, Behavioral ESG of Banks encompasses the concrete actions and practices banks undertake - such as financing green projects, adopting energy-efficient technologies, enforcing strong governance practices, and promoting inclusive lending. Empirical evidence shows that banks with tangible ESG behaviors - especially environmental and governance initiatives - often enjoy greater stability and reduced idiosyncratic risk (Azmi et al., 2021).
The interplay between these two constructs is critically important. When a bank engages in authentic ESG behaviors, these actions reinforce and enhance the credibility of its perceived ESG, thereby strengthening the trust customers place in the institution. In turn, heightened perceived ESG motivates customers to support the bank, deepening loyalty and engagement - behaviors that further incentivize banks to maintain and enhance their ESG actions. This creates a positive feedback

loop: authentic ESG behaviors boost perception, which drives consumer behavior, which supports more ESG behavior.
For example, if a bank undertakes public green financing initiatives and maintains transparent reporting, this elevates perceived ESG. Elevated perceptions then encourage customer retention, word-of-mouth, and even stakeholder advocacy - factors that shape the bank's strategic priorities toward more robust ESG behaviors.

H5: Perceived ESG of Banks (PESGB) positively influences the Behavioral ESG of Banks (BESGB). When consumers perceive stronger ESG commitment, this enhances customer trust and loyalty, indirectly incentivizing banks to engage in more substantive ESG behaviors.

2.7 Perceived ESG of Banks and Trust

Trust is a cornerstone of financial service adoption, particularly in the digital banking environment where users face heightened concerns over data security, fraud, and reliability. It represents customers' confidence that banks will act in their best interests by safeguarding financial information, ensuring transaction integrity, and maintaining long-term stability. At the same time, Perceived ESG of Banks (PESGB) reflects customers' assessment of how authentically a bank integrates environmental, social, and governance practices into its operations. These two constructs are interrelated, as ESG perceptions often serve as a foundation for building or strengthening customer trust.
Empirical studies highlight that ESG performance enhances reputational capital, which directly bolsters consumer trust in banks. For instance, Liang et al. (2025) found that firms with stronger ESG scores enjoyed greater stakeholder confidence and reduced reputational risk. Similarly, Broadstock et al. (2021) demonstrated that ESG disclosure improves investor trust by signaling ethical responsibility and long-term viability. In the banking sector specifically, Belova et al. (2023) emphasized that customers interpret robust ESG practices - such as paperless operations, fair lending policies, and green financing - as signals of institutional reliability, thereby fostering stronger trust in online services.
Theoretically, this relationship is grounded in stakeholder and legitimacy theory. When banks demonstrate a credible commitment to ESG, they legitimize their operations in the eyes of customers, mitigating skepticism and reinforcing confidence. Trust thus becomes both a mediating and reinforcing mechanism: perceived ESG enhances trust, which in turn shapes behavioral intentions such as system adoption, loyalty, and continued usage of online banking platforms.

H6: Perceived ESG of banks (PESGB) positively influences Trust, such that stronger perceptions of ESG commitment enhance customers' confidence in the bank.

2.8 Perceived ESG of Banks and Actual System Use

The construct of Perceived ESG of Banks (PESGB) reflects customers' evaluations of how well a bank integrates environmental, social, and governance principles into its operations. This perception is shaped by observable commitments such as sustainable financing, carbon-reduction initiatives, transparent governance practices, and inclusive financial services. When customers perceive a bank as being authentically committed to ESG, they are more likely to view the institution as trustworthy, responsible, and aligned with their values (Broadstock et al., 2021).

Actual System Use (AU)**,** on the other hand, refers to the extent to which customers actively engage with digital banking platforms in practice - measured by metrics such as login frequency, transaction volumes, and adoption of mobile payment services. Prior studies highlight that ESG perceptions can strongly influence user behaviors: when consumers believe a service provider is sustainable and ethically responsible, they are more likely to engage in repeated usage and adopt new digital services offered by that provider (Liang et al., 2018).

The linkage between PESGB and AU can be explained through the lens of ethical consumer behavior. Customers increasingly integrate sustainability considerations into their decision-making processes, not only in purchasing but also in financial service adoption. For example, Azmi et al. (2021) found that banks demonstrating high ESG performance cultivate stronger reputational capital, which directly enhances customers' willingness to use online platforms actively. In this sense, perceived ESG acts as a motivational driver that translates into tangible system use, reinforcing the strategic importance of sustainability in digital banking adoption.

H7: Perceived ESG of banks (PESGB) has a positive and significant effect on Actual System Use (AU) of online banking platforms.

3. Methodology

3.1 Sampling

To empirically examine the proposed research model and hypotheses on online banking adoption, a structured survey was administered in Taiwan following the COVID-19 pandemic. The data collection procedure followed established methodologies adopted in prior research (Khan and Alhumoudi, 2022). Primary *data* were gathered through an online questionnaire distributed via Google Forms, employing a random sampling approach to ensure representativeness. The survey was conducted between January and March 2023 and disseminated through multiple digital channels, including email and widely used social media platforms such as WhatsApp, Facebook, and Messenger.

Out of 273 questionnaires collected, 23 were deemed ineligible because the respondents indicated no prior use of online banking. Consequently, the final sample comprised 250 valid participants who had experience with digital banking services. While the number of respondents is comparatively limited concerning the larger Indian banking population, this constraint can largely be explained by

individuals' reluctance to disclose sensitive banking information via online platforms. The growing frequency of phishing schemes, fraudulent activities, and cyber scams has intensified skepticism toward electronic communication channels, which likely contributed to the lower response rate, particularly for invitations distributed through email. Nevertheless, the investigation engages with a critical concern: many customers continue to resist the adoption of online banking despite their reliance on traditional banking practices. Participation was entirely voluntary, with confidentiality guaranteed to all respondents. The survey instrument was designed to systematically assess users' perceptions, attitudes, and behavioral intentions regarding the acceptance and use of Internet banking.

The demographic profile of the respondents included variables such as gender, age, educational attainment, occupation, type of banking institution, and length of banking experience. Within the sample, approximately 67% were male and 33% were female. The majority of respondents (43%) were between 30 and 40 years of age, whereas only 5% were above 55 years. Regarding educational qualifications, over half of the participants (55%) possessed a postgraduate degree or higher, while 9.95% had attained less than an undergraduate-level qualification (e.g., a diploma). In terms of institutional affiliation, 61.70% were customers of public sector banks. Additionally, 29.85% of the respondents reported having more than seven years of banking experience.

3.2 Measurement Model Analysis

A core element of Structural Equation Modeling (SEM) is the measurement model, which evaluates the extent to which observed (manifest) variables adequately represent their underlying latent constructs. To establish the validity of the measurement model, tests of reliability, convergent validity, and discriminant validity were performed. Before estimating the structural model, the reliability and validity of the measurement model were examined to ensure an acceptable model fit. Internal consistency was assessed through Cronbach's Alpha (CA), Composite Reliability (CR), Kaiser–Meyer–Olkin (KMO), and standardized factor loadings (Kaiser, 1974).

Factor loadings of 0.50 or greater are widely recognized as an indication of satisfactory construct validity, consistent with established psychometric and SEM guidelines. After confirming data normality and internal consistency, the measurement model underwent empirical validation. The findings revealed that all constructs achieved adequate validity based on accepted standards. Reliability analysis showed Cronbach's Alpha coefficients exceeding the 0.70 threshold for every construct, signifying satisfactory to high internal consistency across the instrument. A comprehensive summary of the reliability and validity statistics is presented in Table 1.

Table 1: Comprehensive Summary of the Reliability and Validity Statistics

Variable	Item	S.E	C.R.	p-value	CA (α)	Factor loadings
Perceived Usefulness (PU)	PU1				0.866	0.579
	PU2	0.138	8.054	0.000	0.825	0.546
	PU3	0.142	8.209	0.000	0.910	0.573
	PU4	0.139	7.742	0.000	0.855	0.588
Perceived Ease of Use (PEOU)	PEOU1				0.899	0.802
	PEOU2	0.152	5.243	0.000	0.909	0.750
	PEOU3	0.125	7.265	0.000	0.852	0.590
	PEOU4	0.114	7.617	0.000	0.911	0.527
Trust	Trust1				0.799	0.806
	Trust2	0.283	4.422	0.000	0.812	0.570
	Trust3	0.291	4.638	0.000	0.888	0.570
	Trust4	0.346	4.832	0.000	0.755	0.611
Perceived Risk (PR)	PR1				0.859	0.735
	PR2	0.173	7.054	0.000	0.892	0.718
	PR3	0.119	8.119	0.000	0.842	0.630
	PR4	0.264	7.624	0.000	0.811	0.655
Behavioral Intention (BI)	BI1				0.746	0.525
	BI2	0.141	7.128	0.000	0.777	0.761
	BI3	0.144	7.115	0.000	0.762	0.688
Perceived ESG of banks (PESGB)	PESGB1				0.788	0.655
	PESGB2	0.278	4.726	0.000	0.752	0.734
	PESGB3	0.226	4.627	0.000	0.714	0.630
	PESGB4	0.256	4.658	0.000	0.825	0.662
Behavioral ESG of Banks (BESGB)	OBA1				0.778	0.791
	OBA2	0.158	4.669	0.000	0.727	0.727
	OBA3	0.163	8.352	0.000	0.791	0.608
	OBA4	0.141	7.668	0.000	0.844	0.562
Actual System Use (AU)	AU1				0.788	0.655
	AU2	0.278	4.636	0.000	0.752	0.734
	AU3	0.226	4.587	0.000	0.734	0.630
	AU4	0.256	4.622	0.000	0.831	0.662

The Pearson correlation analysis (Figure 2) shows consistently positive associations among six constructs: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Trust, Perceived ESG of Banks (PESGB), Behavioral ESG of Banks (BESGB), and Actual System Use (AU). This indicates that improvements in one dimension tend to reinforce others. Notably, PU has strong correlations with both PEOU (0.599) and Trust (0.591), supporting the Technology Acceptance Model's (TAM) central proposition that ease of use and trust significantly enhance perceived usefulness. Additionally, PU is positively related to BESGB (r = 0.562) and AU (r = 0.555), suggesting that both sustainability-oriented behaviors and perceived usefulness contribute to actual system adoption.

Trust also shows moderate associations with PESGB (0.459) and BESGB (0.414), highlighting the importance of perceptions and practices related to ESG (Environmental, Social, and Governance) in building customer confidence. Similarly, AU is influenced not only by PU but also by BESGB (0.518) and PEOU (0.465), reflecting the combined impact of functionality, usability, and sustainability on system usage. The moderate relationship between PESGB and BESGB (r = 0.418) indicates that there is an imperfect yet connected relationship between customers' perceptions and their recognition of actual ESG practices. Overall, these findings emphasize that perceived usefulness and trust are central drivers of adoption, while ESG-related constructs enhance customer confidence and promote sustainable banking behaviors.

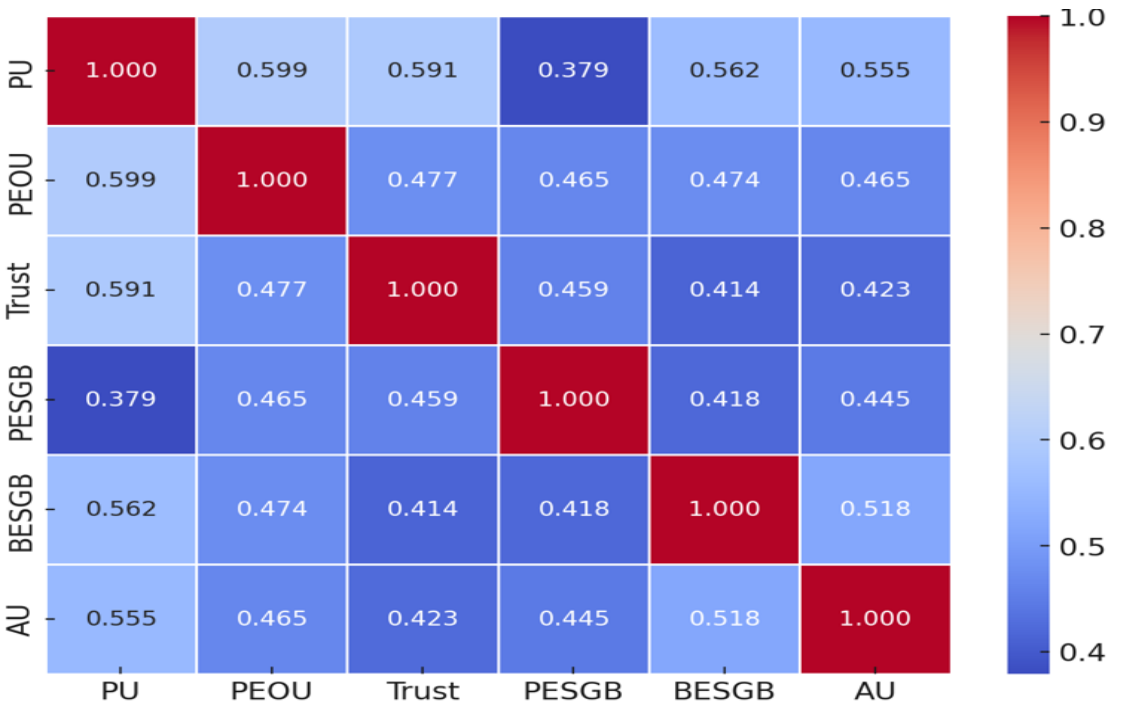

Figure 2: Pearson Correlation Analysis

3.3 Structural Model Analysis

Upon completing the assessments of validity, reliability, and model fit, the structural model was employed to test the four research hypotheses concerning the adoption of online banking in India during the study period. The model parameters were estimated using Structural Equation Modeling (SEM)**,** and fully standardized path coefficients were obtained through the maximum likelihood estimation method in SmartPLS. SmartPLS, a software specialized in Partial Least Squares SEM (PLS-SEM), is particularly suitable for studies with smaller samples and non-normally distributed data. Widely applied in business, marketing, and information systems research, it offers an intuitive graphical interface and supports advanced features such as bootstrapping and multigroup analysis, making it an appropriate tool for this study.

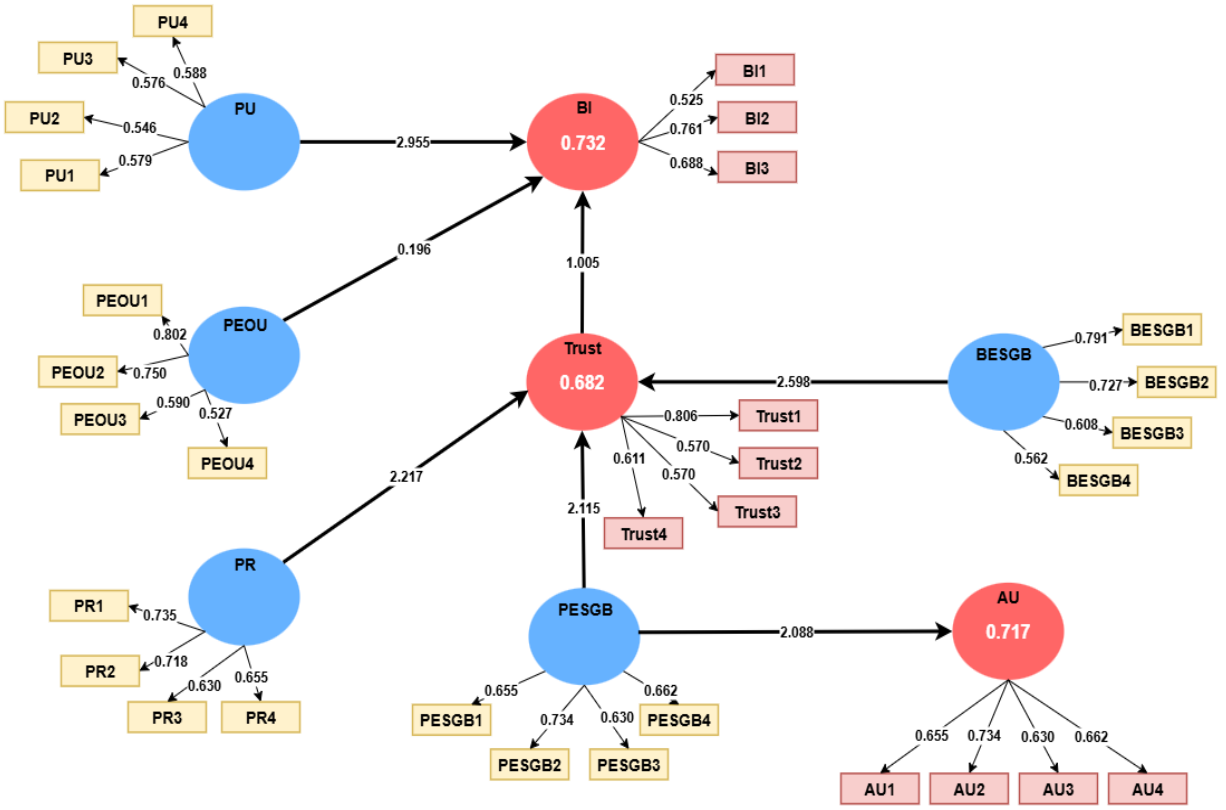

Figure 3: Structural Model Analysis

3.4 Model Fit

After establishing the reliability and validity of the constructs, the overall measurement model was subjected to a goodness-of-fit assessment. As reported in Table 2, a set of commonly applied indices was employed, including the Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), and the Root Mean Square Error of Approximation (RMSEA). The results indicated that the model achieved satisfactory levels of fit, with CMIN/df = 1.936 ($p < 0.001$), CFI = 0.914, GFI = 0.905, AGFI = 0.912, RMSEA = 0.078, and IFI = 0.908. Each of these values meets or closely approximates the recommended cut-off thresholds (e.g., CFI, GFI, AGFI, and IFI ≥ 0.90; RMSEA ≤ 0.08), thereby confirming the adequacy of the model fit (Hair et al., 2012). Taken together, these indices provide robust evidence for the validity of the measurement model, supporting its suitability for capturing the underlying dimensions of bank customers' adoption of online banking services during the pandemic.

Table 2: Model Fit

Statistic	Model fit indices	Recommended value
CMIN/df	1.936	< 3
p-Value	0.000	P < 0.001
CFI	0.914	⩾ 0.90
GFI	0.905	⩾ 0.90
AGFI	0.912	⩾ 0.90
RMSEA	0.078	⩽ 0.08
IFI	0.9077	⩾ 0.90

4. Conclusion

4.1 Discussion

This study examined the adoption of online banking in Taiwan by extending the Technology Acceptance Model (TAM) with additional constructs of trust, perceived risk, and ESG-related dimensions. The empirical findings confirmed the robustness of TAM in explaining adoption behavior, while also highlighting the relevance of sustainability considerations in shaping user attitudes and behavioral intentions. Specifically, the results demonstrated that Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) remain central determinants of behavioral intention, consistent with prior studies on digital finance adoption. At the same time, constructs such as Trust and Perceived Risk significantly influenced adoption, underscoring that customer confidence in data security, transaction reliability, and system integrity is indispensable for sustainable online banking growth.

Notably, the study contributed to the growing literature on sustainable digital finance by incorporating Perceived ESG of Banks (PESGB) and Behavioral ESG of Banks (BESGB). The results indicated that perceived ESG performance

positively influenced both Trust and Actual System Use, while behavioral ESG reinforced customer loyalty and long-term engagement. This finding demonstrates that customers increasingly evaluate banks not merely on efficiency and accessibility, but also on ethical and sustainability dimensions. In particular, the positive link between PESGB and BESGB highlights a reciprocal mechanism: customers' favorable ESG perceptions strengthen banks' incentives to pursue substantive ESG practices, which in turn reinforce consumer trust and adoption behaviors. This interplay reflects a paradigm shift in the financial sector, where sustainability is no longer peripheral but central to strategic digitalization.

The integration of ESG constructs with TAM provides theoretical evidence that online banking adoption is shaped not only by technological and functional determinants but also by ethical consumer behavior and stakeholder legitimacy concerns. The COVID-19 pandemic accelerated this convergence, as financial institutions were compelled to offer digital services while simultaneously responding to social expectations regarding resilience, inclusivity, and environmental responsibility. In Taiwan, where digital literacy and mobile payment infrastructures are highly advanced, these dynamics were particularly visible, with mobile payment penetration expected to reach nearly 90% by 2025. This trajectory suggests that the convergence of FinTech innovation and ESG performance is set to become a defining feature of competitive banking strategies in the post-pandemic era.

4.2 Theoretical Implications

Theoretically, this study enriches the TAM framework by demonstrating that sustainability-related constructs can extend traditional acceptance models. While TAM emphasizes cognitive appraisals of usefulness and ease of use, our findings show that perceptions of ESG and trust also act as mediating and reinforcing mechanisms that shape adoption behaviors. This provides a more comprehensive understanding of online banking acceptance by bridging technology acceptance theory with stakeholder and legitimacy theories. Furthermore, the study responds to calls in the literature for integrating ethical and social dimensions into technology adoption models, thereby advancing the conceptual boundaries of TAM.

Another contribution lies in empirically validating the reciprocal relationship between perceived and behavioral ESG practices. Whereas much of the prior TAM literature focused on individual user perceptions, this study demonstrates that organizational-level ESG actions can directly influence customer perceptions, which then feed back into customer behaviors. This finding emphasizes the bidirectional dynamic between financial institutions and customers in co-creating sustainable digital ecosystems.

4.3 Practical Implications

For practitioners and policymakers, several implications emerge. First, banks must recognize that the perceived usefulness and ease of use of digital platforms are necessary but not sufficient conditions for widespread adoption. Users also demand assurance of system security, robust data protection, and transparent communication of risk mitigation strategies. Investments in cybersecurity infrastructure**,** multi-factor authentication systems, and data privacy frameworks are therefore critical for sustaining customer trust.

Second, ESG engagement is increasingly viewed as a competitive differentiator. Banks that actively promote environmentally friendly operations - such as paperless banking, energy-efficient data centers, or green lending initiatives - can cultivate reputational capital and foster stronger customer loyalty. Communicating these initiatives clearly through sustainability reporting and public disclosures strengthens perceived ESG, which, as shown in this study, positively affects both trust and adoption behaviors.

Third, policymakers such as the Financial Supervisory Commission (FSC) play an important role in promoting digital financial inclusion**.** By mandating accessibility features for disadvantaged populations, encouraging ESG integration, and supporting the establishment of internet-only banks, regulators can foster both inclusivity and sustainability in financial systems. The FSC's initiatives to expand visually impaired-friendly ATMs and enhance digital literacy in rural areas illustrate how regulatory frameworks can reinforce both adoption and ESG goals simultaneously.

4.4 Limitations

Despite its contributions, the study is subject to several limitations. First, the sample size (n = 250), while adequate for SEM analysis, remains relatively small compared to the overall population of online banking users in Taiwan. This may limit the generalizability of the findings, particularly to subgroups such as elderly customers or rural populations who may experience different adoption barriers.

Second, the study relied on self-reported survey data, which is subject to biases such as social desirability and recall errors. Respondents may have overreported positive attitudes toward ESG or trust due to normative pressures. Future studies could complement survey data with behavioral transaction data from banks to provide more objective measures of adoption and system use.

Third, the cross-sectional design restricts the ability to draw causal inferences. While the SEM results establish strong associations among constructs, the temporal dynamics between perceived ESG, trust, and actual use cannot be fully captured. A longitudinal design would allow future research to explore how these relationships evolve over time, particularly as banks scale up ESG initiatives or introduce new FinTech innovations.

Finally, the study was conducted within the Taiwanese context, which benefits from high levels of digital literacy and government support for FinTech. The findings

may not be directly applicable to countries with less developed digital ecosystems or different cultural attitudes toward ESG. Comparative studies across multiple countries could provide more nuanced insights into how institutional contexts moderate the TAM–ESG framework.

4.5 Directions for Future Research

Future research can build upon this study in several ways. First, scholars should explore the differential impact of specific ESG dimensions (environmental, social, governance) on online banking adoption, rather than treating ESG as a single construct. This could reveal whether, for example, environmental initiatives carry more weight with customers than governance practices.

Second, future studies should examine demographic moderators such as age, education, or income in shaping the relationships between TAM constructs, trust, and ESG perceptions. Understanding generational differences in attitudes toward ESG-driven digital banking may provide practical guidance for tailored strategies.

Third, researchers could extend the model by incorporating emerging constructs such as AI-driven personalization, financial well-being, or digital literacy, which are increasingly relevant in the evolving FinTech landscape. These dimensions could interact with ESG to shape both adoption and customer satisfaction.

Lastly, more comparative and longitudinal studies are warranted. Cross-country comparisons between advanced economies (e.g., Taiwan, Singapore) and developing economies (e.g., India, Indonesia) could illuminate how institutional support, regulatory frameworks, and cultural values influence the ESG–TAM nexus. Longitudinal studies could further trace how crises (such as pandemics or financial shocks) accelerate or hinder the convergence of digitalization and sustainability in banking.

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