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Greening Digital Finance in Malaysia: An Empirical Assessment of Capabilities, Credibility, and User Trust in FinTech-Enabled Sustainable Finance

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Abstract

Green Digital Finance is increasingly seen as a crucial vertical for propagating Malaysia's sustainability agenda with the sector, but there are mixed levels of credibility and substance in terms of environmental claims associated with FinTech offerings. The contribution of this paper is to perform a more comprehensive empirical study on technological, organizational and behavioral factors influencing the integrity and diffusion patterns of green digital finance. Based on the Technology–Organization– Environment (TOE) framework, Diffusion of Innovations (DOI), and Islamic finance governance theory, this study adopts a mixed-method approach consisting of three interrelated parts. The first step involves the development and application of the Green FinTech Evaluation Matrix (GFEM) to eight FinTechs for assessing intent clarity, alignment with the GHGTEA taxonomy, quality of data, assurance, integration into governance processes, transparency and early signals of success. Twenty-four expert interviews with regulators, FinTech CEOs, ESG experts and Shariah scholars revealed capacity gaps and fragmented governance structures in the delivery of new regulations like Climate Change and Principle-based Taxonomy (CCPT), and its resulting operational challenges. Third, a survey experiment involving 432 users illustrate how assurance cues, information disclosure depth and CCPT alignment affect trust, perceived environmental impact and adoption intention. Findings show that only a low proportion of providers have robustly sustainable features and integration of assurance and governance are continuing structural weaknesses in entire sector. The experimental results demonstrate that external assurance, dual ESG–Shariah verification and clear methodological disclosures are found to be significant in improving user trust and adoption, with the mediating role of trust in major findings.

1. Introduction

Digital finance is transforming how people save, invest, pay and borrow. In Malaysia, the change is also in line with national aspirations for sustainability and climate adaptation. "Green" features like carbon calculators, ESG portfolios, sustainable loan incentives and behavioral nudges appear on many FinTech products today. But vital questions remain: What, exactly, makes a product "green"? How credible are these claims? Are users willing enough to trust and/or adopt the products in order to increase financial or environmental performance?

These concerns are relevant in the context of the dual financial system in Malaysia, as well as under BNM's Climate Change and Principle-based Taxonomy (CCPT). CCPT provides guidance for policy, but is vague about how FinTech products would apply though. Amid fears of global greenwashing, verification, governance and transparency are crucial. Rapid innovation in FinTech could multiply these risks -if claims are not evidence-based.

Little research has focused on Green FinTech. Most studies focus on sustainability reporting or ESG investing, not product design, taxonomy alignment, assurance or trust. And, even fewer literature on the Islamic finance governance which very much influence credibility in Malaysia.

This paper fills these gaps. It consists of 4-items that relate to CCPT alignment, enabling conditions, trust cues (i.e. assurance and Shariah compliance) and antecedents towards early output signal. It presents a Green FinTech Evaluation Matrix (GFEM) that rates products across seven criteria: clarity of intent, taxonomy alignment, quality of data, third-party assurance provision, ESG/Shariah governance disclosure transparency and early results.

The study uses mixed methods. It rates six to eight providers, interviews regulators and industry experts, and runs a user experiment on trust cues. It encompasses the TOE, DOI, sustainable finance and Islamic governance theories. It endorses GFEM.HE and charts Malaysia's Green FinTech landscape. CCPT implementation, and mitigating the greenwashing pitfall, and trust building.

2. Literature Review

2.1 Green Digital Finance and Sustainability Transitions

The role of digital financial technologies is particularly important in addressing sustainability challenges, given that investors will need insights into the sources of both risks and opportunities in relation to environmental issues.

Digital finance has, more recently, been framed as a facilitator of sustainability transitions including through: greater access to low-cost financial services; improved data availability for investments for positive environmental impact; and the rise of new forms of environmentally-aligned investment and credit. On the cryptocurrency front, authors suggest that digital financial platforms could be used to fast- track green behaviour by incorporating sustainability signals, nudges and decision-support systems into user interfaces (Gomber et al., 2018; Ozili, 2020). In developing countries, the growing prevalence of mobile payments, robo-advisory platforms and digital banks provides new options to nudge consumer financial decisions toward national climate objectives (Arner et al., 2020; Berg et al., 2022). This inconsistency is a cause for concern about greenwashing, and it also implicates the necessity of providing clear standards that distinguish between types of green features (substantive or largely symbolic). These (this) benchmarks would then be feed into a policy initiative such as the Climate Change and Principle based Taxonomy (CCPT), which shifts focus from policy ambitions to product-level measurement, reporting, verification in a market context.1 In fall 2019, Malaysia is building sustainability consideration into its financial sector guidelines and will need to translate taxonomies like the CCPT into practical implementation.

2.2 Taxonomies, Disclosure Quality and the Risk of Greenwashing

My analysis revealed how taxonomies act as ordering devices that tether sustainability claims to auditable economic practices. At the international level, the EU Taxonomy has set a reference for labelling green investments whereas the ASEAN Taxonomy and CCPT provide regionally adapted frameworks. However, taxonomies are only effective in enhancing market discipline if firms disclose data at the level of disaggregation required for validation (Fatica & Panzica, 2021). De facto, disclosure across FinTech providers is still very patchy in what concerns funded emission, asset categorization or sustainability metrics. Research on ESG products suggests that definition ambiguities and weak assurance may undermine the confidence of users and create space for greenwashing (Boffo & Patalano, 2020). These risks are compounded by digital finance where product cycles are rapid, marketing is highly visible and claims aren't usually supported with transparent methodological notes. For Malaysia, the CCPT provides a principles-based framework (as opposed to a bright-line test) which increases flexibility, but leaves also room for guidance in how these can be operationalized at product level. In the absence of widespread adoption, CCPT-aligned features might be aspirational rather than measurable.

2.3 Technology–Organization–Environment (TOE) and Capability Formation

The TOE theory represents a strong framework for identifying influencing factors when organizations introduce new technologies such as those related to S. In terms of TOE, technology readiness entails providers' data systems, analytics capability and digital infrastructure; organizational readiness includes governance structures, leadership support and skill base internally; while environmental readiness constitutes regulatory requirements, market competition and institutional norms (Tornatzky & Fleischer, 1990). The literature demonstrates that sustainability innovations demand a strong interplay among these dimensions (Bai et al., 2020). For Green FinTech, data pipelines to estimate emissions, for risk modeling and product mapping in taxonomies are essential tech capabilities. Organisational drivers of credibility Organisational factors such as structures of ESG and Shariah governance, board oversight as well as assurance mechanisms influence credibility. Second, outside-in learning: CCPT and ESG

reporting standards constitute the institutional environment that pressures firms to improve capabilities. That said, maturity among digital providers varies widely and so “green” claims could be based on very different underlying processes. An empirical capacity assessment is therefore necessary to differentiate strong from weak levels of sustainability integration.

2.4 Diffusion of Innovations (DOI), Trust, and Adoption Behavior

At the microlevel of individual consumers, how and when individuals accept new technologies can be explained by the Diffusion of Innovations theory in terms of perceived relative advantage, compatibility, complexity, trialability and observ- ability (Rogers 2003). Regarding Green FinTech, these are found in Interface design, degree of clarity around disclosure and visibility of impact on the environment. Studies indicate that in order to achieve user adoption of green financial tools, eco-friendly claims should be credible and comprehensible (Chen & Chang, 2013). Credibility stands out as the key mediating factor; users need to perceive environmental characteristics to be real, practical, and congruent with their beliefs. According to digital finance research, trust could be influenced by perceived security and usability as well as the credibility of sustainability cues (Sharma & Rather, 2021). Credibility markers, full disclosures above indications and third-party authentication are likely to enhance/cannibalise overall perceived credibility of green claims. If environmental and ethical validation are combined in a product, the likelihood of adopting it is much higher. Therefore, DOI provides a counterpart on the consumer level to TOE’s organization level of analysis, which in turn facilitates a synergetic explanation of Green FinTech outcomes spanning two levels.

2.5 Assurance, Verification, and Islamic Finance Governance

Independent assurance has become an important tool to boost the credibility of ESG reporting. Research shows that trust is increased and perceptions of greenwashing are reduced when assurance, from auditors, ESG (Environmental Social Governance) rating providers, or other industry specialists, is in place (Velte & Stawinoga, 2020). For digital financial products, assurance can be provided in the form of validated carbon metrics, certified ESG portfolio approaches and third-party confirmation of impact claims. Despite the above cost, absence of standard methodologies and maturity of regulations are on the reasons behind the fractured practices for Assurance in FinTech.

Islamic finance governance, in Malaysia’s two-tiered financial system, provides a second path to credibility. Shariah screening, traceability of fatwa and monitoring by Shariah committees expand the ethical alignment beyond environmental considerations. Studies have shown that Shariah-compliant labellings are seen as signals of transparency, trustworthiness and risk reduction by Muslim users (Dusuki & Abdullah, 2007). The inclusion of Islamic governance with sustainability disclosures results in a compound ethical legitimacy which can significantly influence user acceptance. It is thus this two-tier governance system where Malaysia is unique relative to other markets and the theoretical and empirical models that can analyze both the environmental and faith-based strands (together).

2.6 Connecting Green FinTech Quality to Outcome Signals

The contribution from digital sustainability is seldom documented in long-term environmental results because of the challenges of attribution and lack of data. Instead, it is the role of scholars to focus on early outcome signals—intermediate indicators showing how we are progressing with regards to sustainability targets (Kölbel et al., 2020). Examples include higher green AUM share, further increase in origination of sustainable loans, better emissions-related disclosures or increased user engagement with carbon calculation tools. These signals do not prove causality, but provide directional evidence that products are influencing money flow and user behavior. In FinTech, these signals may be encoded in app-driven dashboards, investor reports or transaction-level attributes. Yet, because the quality of disclosure varies greatly among providers, a quantitative assessment tool is necessary to compare signals across

platforms. Addressing this gap the GFEM model presented in this paper offers a systematic connection between product features and governance structures with observable early signals.

2.7 Synthesis and Research Gap

In summary, the literature brings out three open questions. First, Green FinTech statements are not evaluated according to a standard set of criteria which transforms taxonomies and governance principles into measurable product features. Second, needs for the green integration credibility in FinTech are largely unclear not only in emerging markets with dual-coordinate governance and market system. Third, very little empirical evidence is available with respect to the impact of different design cues (e.g., assurance, Shariah compliance) on trust, adoption and willingness to pay among users. These lacunae would necessitate an inclusive mixed methods analysis that encompasses organizational capabilities, policy rails, product-level attributes and user behavior in one common empirical context.

3. Conceptual Framework and Hypotheses Development

3.1 Introduction to the Theoretical Model

The theoretical framework of this paper draws the organizational, technological and consumer-level insights to understand how GDF features are designed, governed and adopted in an emerging market's sustainability ecosystem of Malaysia. Grounded in the Technology–Organization–Environment (TOE) framework, Diffusion of Innovations (DOI), and a nascent stream of literature at the intersection of sustainability assurance and Islamic finance governance, the model locates capability building, governance quality and taxonomy congruence as primary enablers influencing product credibility. Such drivers affect the way in which users perceive trust in the sustainability claims, environmental characteristics and then make decisions on whether to use or interact with the products. The model also includes early outcome indicators for useful objects as part-way targets of product usefulness recognizing that the ultimate environment impact has to manifest itself within conventional study timeframes. Collectively, these factors offer a coherent trajectory from product inputs through to behavioral and organizational outcomes as evidence supporting the multilevel nature of Green FinTech systems.

3.2 Level of Technology Readiness, the Integrity of Green Features

Application layer The underlying application technology of digital financial products is realized by the position. Some examples of such tools are data analytics instruments, or emission estimation calculators or processes classification/automation machines and digital interfaces including the indication that sustainability is embedded in green finance. Quality of data Few report sources note that poor-quality infrastructure was giving rise to both unreliable, and unverifiable claims about environmental responsibility, which may heighten the risk of green-washing (see eg At the other end of this continuum, robust data connectivity also enables providers to connect financial transactions or portfolio to environmental metrics like carbon footprints and taxonomy-aligned activities. With CCPT adherence set to become more of a focus in Malaysia, the FinTech space will need to develop systems that can handle those CCPT rules as well as screening algorithms and live data monitoring. The construction of such a system is an integral piece in the puzzle if we want sustainability and all its associated themes to be more than tokenism or pure rhetoric, but it must be underpinned by strong pillars.

As service providers make such investments, the credibility of green attributes increases thus reinforcing users' perceptions about their authenticity and trustworthiness. According to this logic, technological capacity is predicted to benefits both the quality and reliability of GDF products.

Hypothesis 1

Higher levels of technological capability among FinTech providers are positively associated with enhanced integrity of green digital finance features.

3.3 Organizational Governance and the Credibility of Green Claims

Organizational governance is critically important for the operationalization of sustainability goals. Sustainability integration in the literatrure We found that literature emphasises a central role for governance, with leadership commitment as well as an ESG unit and other mechanisms such as internal controls or oversight (Velte & Stawinoga, 2020). For digital finance services, the quality of governance matters in deciding whether environmental claims are internally validated, externally assured or misleadingly promoted through marketing. In Malaysia, governance also refers to the set-up and operations of Shariah boards that assess ethical conformance and issues fatwas asscoiated with product design. Shariah governance results in increased consumer confidence as it signals ethical values and mitigates information asymmetry (Dusuki & Abdullah, 2007). When paired with ESG governance, this dual system would enhance the credibility of green attributes. Differences in organizational factors thus go beyond structures to include cultural beliefs, transparency, and compliance behaviors affecting claim initiation and reporting. These dimensions imply that corporate communication with strong governance is more likely to yield clear, credible and verifiable green disclosures and thus lower perceived impression of greenwashing.

Hypothesis 2

Stronger organizational governance structures are positively associated with higher credibility of green digital finance disclosures.

3.4 Environmental and Policy Alignment with CCPT and ESG Standards

Providers are pressured by forces outside of their control, such as regulators' expectations, industry standards and taxonomies to fit digital products around national sustainability priorities. CCPT offers 5 key categories of classification, from climate-supporting activities to prohibited and encourages financial institutions to adopt a principles-based approach. Flexibility in interpretation though potentially generalizable may lead to inconsistencies in application when not undergirded by specified product-level interpretations (Fatica & Panzica, 2021). By pledging to align with CCPT standards, providers announce that their products meet nationally supported environmental requirements. Previous evidence shows that alignment with transparent taxonomies can enhance market discipline, transparency and the verifiability of environmental claims (Boffo & Patalano, 2020). Regarding the CCPT alignment for FinTech platforms under competitive market pressure, which shall in turn contribute to their environmental legitimacy. Taken together with ESG disclosure requirements, regulation may be the game-changing environmental force that influences product design and builds user trust. Even if they do, it also gives us a common definition that can be useful to classification and policy dangers of greenwashing.

Hypothesis 3

The closer relationship between the FinTech products and CCPT and ESG policy, the higher green financial attributes process, maturity and transparency will be.

3.5 Assurance, Verification and Confidence-Building Measures

Independent assurance and third-party verification has become of a growing interest these as mechanical tools on which to evaluate the sustainability claims. Research on assurance reveals an impact on trust among customers, less perceived greenwashing and improvement in the credibility of ESG communication (Velte & Stawinoga, 2020). In FinTech, such assurances might look like certified carbon metrics, externally assured impact methodologies, verified green portfolios or standardized scoring.

These approaches help users to distinguish between inflated marketing and genuine green products. For Muslim customers, double assurance – sustainability being certified as Shariah compliant – is an even greater faith signal. Ethical certification that works in conjunction with environmental assurance is achieved through shariah rulings, testing procedures and fatwa documentation. And when a consumer finds products with both types of verification on-pack, they see the best of both worlds in terms of verifying product authenticity and ethical supply chain practice. The mediating role of trustTrust is thus a mediating variable between product design characteristics and adoption behavior. Accordingly, trust is presumed to be significant in influencing user attitudes.

Hypothesis 4

Green digital finance products with external assurance or dual assurance (ESG and Shariah) are associated with higher levels of user trust.

3.6 Trust and Adoption Intent in Green Digital Finance

Consumer confidence is widely acknowledged as a key driver of technology acceptance. Based on DOI, intention to use is driven by the belief that an innovation has advantage, low-risk, compatible values and easy for adoption (Rogers 2003). When the green attributes are well communicated and verified in an ethical manner, then lower perceived risk and higher perceived value is felt by the user. Past studies have reported that green trust is a significant predictor of intention to purchase environmentally friendly products, such as sustainable financial services (Chen & Chang, 2013). In the context of Malaysia, trust is influenced by cultural and religious values; hence transparency and ethical compliance become more noteworthy. A credible and user-friendly FinTech product which communicates in understandable ways how it resolves potential environmental malpractices, verifies claims thereof, or ensures compliance with Shariah indeed sends a message the other way round. Trust can hence be seen as a mediating construct to account for the ways in which governance, technology and assurance have effects on behaviour. The model therefore hypothesizes that the more trust the less theft, and theft is associated with lower intent to adopt.

Hypothesis 5

Higher levels of user trust in green digital finance products are positively associated with stronger intention to adopt such products.

3.7 Early Outcome Signals and Perceived Environmental Impact

Green FinTech solutions have been compromised as they generally run on truncated test cycles, meaning that longer-term environmental benefits are difficult to quantify. As a result, early indicators of progress are important to signal movement, such as higher user engagement with environmental dashboards, higher uptake of green investment options, or better habitual consumption patterns from nudges. They are not an unequivocal evidence for environmental amelioration, but they signal that the direction of change is concomitant with sustainability targets (Kölbel et al. For those perceiving such outcomes, users might have positive influence on environmental effect and be even more likely to adopt and be satisfaction. Payers with competent technological and governance capacities will produce obvious meaningful early signals on the product effectiveness. When early signals are perceived as visible

and credible, they reinforce the psychological connection between using a product and engaging in pro-environmental behavior. The existence of such signals thus also increases perceived impact, which in turn affects the overall rate adoption and use over time.

Hypothesis 6

The strength of early outcome signals generated by green digital finance products is positively associated with users' perceived environmental impact.

4. Methodology

4.1 Research Design

To investigate the complexity of GDF creditability and capability, user trust, as well as adoption intention in Malaysia, this research employed a mixed method approach. Instead, Green FinTech is a subject that unfolds across many levels of analysis and intervention— from technological infrastructures and governance institutions to policy dynamics to product design and consumer practices—and therefore may not be well served by any one methodological point of view. The method of empirical mixed design uses a three-pronged approach: (1) systematic product and document analysis with the Green FinTech Evaluation Matrix (GFEM), (2) semi-structured expert interview for exploring organizational, regulatory, or governance drivers, and finally an (3) quantitative user survey experiment to investigate the effect of assurance cues taxonomy alignment and disclosure quality towards vis-a-vis acceptance.

This multi-method approach follows previous sustainability research by noting the importance of triangulation, contextual interpretation and multiple sources of evidence when working with emergent constructs that do not have agreed measurement standards (Creswell & Plano Clark, 2018). It also extends to the point concerning research in digital finance where users, technology infrastructures and institutional practices entwine in producing innovation trajectories. These three sets of evidence taken together give a comprehensive evaluation on legitimacy and efficacy of greenFinTech features in Malaysia.

4.2 Study Design and Case Selection Model

The case study as a research strategy was adopted in this paper so that detailed information could be gathered on the problem of interest. The study's sampling strategy adopts a purposive approach focusing on relevance, variation and representation in Malaysia's digital finance ecosystem. For the product-level GFEM review, a subset of six to eight FinTechs are chosen to reflect some key categories that sustainability based features begin to appear in. Categories within these include digital banks, e-wallet providers, robo-advisers and digital SME lenders. Product selection is based on two factors, explicit sustainability features or claims and market relevance – user adoption, regulatory engagement or public profile. This sampling logic intends to include best practices, emerging innovations and possible red flag regarding greenwashing. Following case study methodology (Yin, 2018), cases serve as the analytical units providing a variety of perspectives in terms of depth and proficiency in sustainability integration across the sector.

At the qualitative level, 20–24 experts (regulators, industry executives, sustainability practitioners, Shariah governance scholars and independent assurance providers) are interviewed. Respondents are sourced via professional social networks, regulators' directories, environmental sustainability forums and snowball sampling. The selection allows representation from conventional, Islamic perspectives (Malaysia is operating on the dual financial system) and also reflects the role of ethical governance in building trust towards users. For the quantitative study, we aim for at least 300–500 users, in line with statistical power considerations regarding medium-sized effects in between-group

experiments (Cohen, 1992). Survey Respondents will be recruited via online survey panels, young university networks, and targeted social media advertising to promote demographic heterogeneity with respect to age, income, digital proficiency and religious orientation. These strategies for sampling in combination help provide robust, multi-perspective evidence.

4.3 Development of the Green FinTech Evaluation Matrix (GFEM)

The GFEM, as the main tool, aims at a comprehensive assessment of the credibility, integrity and impact-orientation of GDF products. The process of GFEM development is designed following guidelines on sustainability assurance standards, ESG taxonomies, digital product design principles, and the CCPT framework. The EU Taxonomy, IFC Operating Principles for Impact Management and AA1000 Assurance Standards offer useful perspectives though neither of the three is specifically related to FinTech or digital product execution. Thus, GFEM involves seven dimensions which reflect structural and behavioral considerations: clarity of intent; alignment with the taxonomy; quality of environment-related data; third-party assurance; integration governance ESG and Shariah compliant governance; user transparency, early outcome signals. Each dimension contains operational measures that map points of a product or disclosure to measurable criteria. The grading is on a sliding scale, allowing for comparisons between different products and capabilities.

The matrix is used on two smaller, non-main study based digital products in order to further refine scoring criteria, reduce ambiguity and test inters rater reliability. The pilot GFEM scores are scored by two blinded sustainability professionals, and discrepancies are used to enhance construct clarity. This is consistent with the methodological advice to refine new sustainability measurement scales and devices so as to improve their validity and reliability (Linnenluecke & Griffiths, 2013). Our authors' final generic functional expansion model (GFEM) is in turn used systematically with selected cases to describe scores, visualize patterns, capability bundles and common weaknesses in the sector.

4.4 Interview Protocol and Qualitative Procedure

The qualitative part of the research is seeking to discover organizational capacity, governance motivation and contextual factors that impact on the development process of GDFs and user confidence. Semi-structured interviews are employed as these allow for investigation of emergent themes to remain comparable across participant groups. The interview guide is structured around questions in relation to sustainability strategy and risk literature, taxonomy adoption, issues with data, assurance mechanism established for the framework and Shariah governance processes, and potential user expectation of Sukuk investors. Pooling from institutional theory and sustainability governance literature that follow the path of pressures, norms and power structures in such behavior (Scott, 2014), the protocol is guided. Interviews take place in person, or when necessary telephonically or with a secured online approach according to participants availability.

All interviews are audio-taped with permission and transcribed in full. The transcripts are subject to theme analysis, drawing on Braun and Clarke (2006) six steps. Codes are organized, patterns identified, and relations between governance practices, technological capabilities and sustainability intentions are coded and mapped with NVivo software. Thematic saturation is checked to ensure that new interviews do not reveal new concepts and thus validity is reinforced. Interview findings provide contextualization for GFEM scores, rationale for differences in products and ecosystem-wide capacity gaps. This type of discourse also influences the construction of the experimental treatments in the survey.

4.5 Design and Measures of Survey Experiment

The quantitative part of the study includes between-groups survey experiment to investigate the causal relationship between perception of sustainability cues and user trust, as well as adoption intention. Leveraging this novel methodology, participants are randomly exposed to one of a number of mock digital financial product interfaces that differ in the type of assurance cues (none, external assurance, dual ESG–Shariah assurance), alignment statements with taxonomy and level of disclosure. The experimental manipulation design has been conducted in accordance with best practice procedures as recommended by the behavioral literature whereby visual stimuli mimic naturalistic digital product environment to increase ecological validity (Aguinis & Bradley, 2014). Following exposure to the stimuli, participants are asked to respond to trust, perceived environmental impact, perceived risk and clarity of information constructs as well as behavioural intention to adopt the product.

The scales are based of existing validated constructs in the literature. The scale for green trust is adopted from Chen and Chang's (2013) study, where scales for perceived risk and information transparency are also borrowed from previous digital finance adoption researches (Liébana-Cabanillas et al., 2018). Adoption intention is designed using conventional behavioral intention models (Technology Acceptance Model and DOI). Likert-type scales from 1 (strongly disagree) to 7 (strongly agree) are employed to enable sensitivity across the range. Demographic details and digital skills gained are also gathered for controlling purposes.

4.6 Data Analysis Procedures

Analytic approach Analysis occurs in multiple phases to synthesize findings across the mixed methods design. Specifically, GFEM results of the product analysis are statistically summarized in order to find trends, strong and weak aspects among the sample. The type of correlation analysis taking place is an investigation into the association between GFEM dimensions and apparent product attributes. Second, the qualitative themes derived from interviews are integrated and associated with GFEM dimensions for cross-validation and deeper construct interpretation. Qualitative and quantitative syntheses are developed based on a convergent parallel design, a common mixed methods research method (Creswell & Plano Clark 2018).

For empirical data, reliability analysis is employed to evaluate the internal consistency of measurement scales in terms of Cronbach's alpha. Construct validity is confirmed by factor analysis. Post hoc comparisons among groups are performed by appropriate between group comparisons multiple regression and ANOVA models. The mediation analysis, based on the methods of Hayes (2018), is performed to test whether trust serves as an intermediate variable between sustainability cues and adoption intention. The combination of experimental results with GFEM and interview perceptions enable us to provide a rich account of how on one hand product characteristics, assurance measures and governance setups shape users' perception and behavior.

4.7 Ethical Considerations

Ethical approval

was not required for this study. All participants were adults and gave informed consent.

5. Results

5.1 Overview of Analytical Approach

Findings are reported in three parts as they relate to the multi-method design of the study. First, the scores of the Green FinTech Evaluation Matrix (GFEM) are reviewed to evaluate good governance, taxonomy consistency, assurance standards and transparency quality of sustainability characteristics for FinTech providers in our sample. Second, insights identified through expert interviews are condensed to describe capacity gaps, governance challenges, and

ecosystem bottlenecks in product-level ratings and implementation quality. Third, the quantitative experiment is examined to assess how cues of sustainability—assurance, taxonomy alignment and disclosure depth—influence user trust, perceived environmental impact and intention of adoption. Collectively, the results provide a coherent picture of how organizational capabilities, governance mechanisms and product design work together to affect both the credibility and adoption of Green Digital Financial products in Malaysia.

5.2 GFEM Product Assessment

The GFEM scores showed a wide variation of the quality and trustworthiness in how the green digital finance features were provided, by eight FinTech platforms. Table 1 Composite and dimensional scores are summarized. In general, two products — a digital bank and a robo-adviser — showed more advanced practices of sustainability integration, stemmed from strong data systems, clear transparency of disclosure and connections to established ESG methodologies. By comparison, many e-wallet suppliers had only basic depth even away from general environment messaging with poor taxonomy alignment and little in the way of assurance.

Most providers adopted clear intent clarity, in particular, sustainability messages frequently appeared on marketing materials. However, taxon assignment tended to be superficial with the CCPT, and it was often based on high-level assertions rather than a rigorous taxonomy. Only three companies exhibited consistent categorization routines which aligned product attribute to CCPT groups. Data quality varied widely. Companies with more sophisticated emissions estimation models, or verified ESG datasets scored significantly higher while a portion were based on generic or non-verifiable carbon claims.

Assurance was the value weakest area throughout the ecosystem. Only a single provider referenced third party assurance of environmental metrics, and two providers showed partial ESG assurance in relation to parent-company reporting cycles. None of the providers offered full dual assurance with combined ESG and Shariah verification, even though the dual system is applicable in Malaysia. Scores for transparency were better when providers provided dashboards, bolded methodologies or real-time indicators of impact. Early outcome signals comprised four providers that had developed early indicators for the most part portfolio greenness measures, user carbon-tracking dashboards and trended patterns of selective uptake of sustainable loans.

Table 1
GFEM Scores for Green Digital Finance Providers

Provider	Intent Clarity (0–5)	CCPT Alignment (0–5)	Data Quality (0–5)	Assurance (0–5)	ESG–Shariah Governance (0–5)	Transparency (0–5)	Early Signals (0–5)	Composite Score (0–35)
P1 – Digital Bank	5	4	4	3	4	5	4	29
P2 – Robo-Advisor	4	4	5	2	4	5	5	29
P3 – E-Wallet	4	2	2	1	2	3	2	16
P4 – E-Wallet	3	2	1	0	1	2	1	10
P5 – SME Digital Lender	4	3	4	2	3	4	3	23
P6 – Digital Bank	5	3	3	1	3	4	3	22
P7 – Robo-Advisor	4	4	4	1	3	4	4	24
P8 – SME FinTech	3	2	2	0	2	3	2	14

The GFEM findings suggest most organizations have structural gaps in assurance, taxonomy application and governance integration. They also indicate the existence of credible practices among a minority of providers that might act as a virial for sector-wide improvement if buttressed by informed policy and capacity-building programs.

5.3 Qualitative Findings of Expert Interviews

The qualitative analysis identified six dominant themes explaining the patterns noticed between the GFEM findings: lack of capability, ambiguity when it comes to implementation of CCPT, low preparedness for assurance, disconnects in ESG and Shariah governance, poor data architecture design and users consciousness deficit.

Respondents highlighted that in many cases, digital finance providers currently lack specific sustainability capabilities – such as the capacity to interpret taxonomies and estimate emissions methodologies. While the CCPT offers some rules of thumb, respondents indicated that there was inadequate product specific guidance to facilitate consistent interpretation. It is such vagueness that feeds the pretense of comity among most providers. Some ecosystem actors also described CCPT as being “clear at the principle level and tough in the operation” especially because FinTech products are not easy to map to traditional economic activities for which they were measured with CCPT.

Confidence is one of the most frequently cited concerns. Sustainable assurance providers, auditors and ESG consultants said few FinTech companies are ready for third-party verification – whether that is due to lack of data governance, immature methodologies or the price tag remains up in the air. Analysts emphasized the need for

standardized metrics and audit-quality data sets. Islamic finance specialists have also noted the shortage of full-fledged certainty mechanisms that deliver a joint certification for ESG and Shariah guidelines, instead of the existing market-driven approach.

Another point in common was fragmention of governance. Providers Few providers operate with separate ESG and Shariah arms, and there is limited cooperation in green product development. Respondents noted that, since many digital solutions concentrate on sustainability and have passed through ESG practices, there is no systemic Shariah input (or it travels in the opposite direction), which means partial ethical validation.

Restricted data was prevalent throughout all parts. FinTech organisations faced challenges in sourcing data on verified emissions and credible ESG categories, especially for SMEs and retail consumption. Regulators and industry specialists agreed that digital finance providers were overly dependent on generic data unsuitable for defensible sustainability claims.

Respondents noted too that in Malaysia, users of information are more interested in ethical and environmental finance now than previously, but know little about taxonomies, impact methodologies and assurance processes. This vacuum emphasizes the crucial role for trust signals such as brand, Shariah certification and other third-party support.

5.4 Quantitative Experiment Findings

The survey experiment yielded 432 usable responses. Descriptive statistics revealed the sample was diverse in terms of demographics and most exhibited strong digital adoption. Manipulation checks of the experiments ascertained that participants noticed differences in cues for assurance, depth of disclosure and alignment between CCPT across stimuli.

Two-way mode analysis and ANOVA tests indicated that there were significant effects of sustainability cues on trust, perceived environmental impact and adoption intention. The differences in trust scores between products that did or didn’t provide external assurance were significantly higher. For the combined confirmation of ESG and Shariah, it was found that the highest score was seen if products indicated a double guaranty. Reaction to taxnomy alignment statements A photo of taxonomy alignment statements by CCPT raised credibility further, especially for participants with knowledge on sustainable finance". There were also significant effects of the depth of disclosure: greater transparency and lower perceived risk were found for descriptions including specific methodology.

Trust proved to be a powerful moderator between sustainability cues and adoption intention. The direct effects of assurance, alignment and disclosure on trust are depicted in Table 2.

Table 2
Regression Model Predicting Trust in Green Digital Finance Products

Predictor	Coefficient (β)	Standard Error	t-value	p-value
External Assurance	0.42	0.07	6.12	< 0.001
Dual ESG–Shariah Assurance	0.58	0.08	7.41	< 0.001
CCPT Alignment Statement	0.31	0.06	5.08	< 0.001
High Disclosure Depth	0.27	0.05	5.39	< 0.001
Constant	2.11	0.14	15.07	< 0.001
Model R^2	0.49	—	—	—

ANOVA findings further indicated that assurance type had a significant influence on the perceived environmental consequences ($F = 32.14$, $p < 0.001$). Double assurance generated the highest perceived impact scores, so the combination of ethical and environmental validation is a strong credibility signal. Moderated mediation analysis, by using the Process Model 4 suggested Hayes, verified that trust played a partial mediating role in the relation between sustainability cues and adoption intention (indirect effect = 0.19, 95% CI [0.11, 0.28]). This reveals clear, certified green features stimulate adoption mainly by enhancing user confidence.

Table 3
Mediation Analysis: Trust as Mediator Between Sustainability Cues and Adoption Intention

Path	Coefficient	SE	95% CI
Cues → Trust	0.48	0.06	[0.37, 0.59]
Trust → Adoption	0.39	0.07	[0.25, 0.52]
Indirect Effect	0.19	0.04	[0.11, 0.28]

5.5 Integration of Mixed-Methods Findings

An overview of our findings summarized in the synthesis is consistent evidence at across products, organisations and users levels. High GFEM scores strongly reflected interview themes, including strong data systems, integrated governance and preparedness to proceed with assure. Key product providers of GFEM Participants that were the primary suppliers of products to the market for GFEM, this was confirmed through interview by role in emerging markets and having more advanced internal capabilities and ecosystem interfaces. In addition, the qualitative repetition enabled to interpret weak dimensions of GFEM: Sureness (taxonomic congruence), Interviewee attributions (Absence of ability) and Structural GAP.

Our findings especially confirm these propositions since it appears when users see the same dimensions (assurance, alignment and disclosures) simultaneously enriched, their trust and intentions to use are greater. Since the trusted and reliable rank clearly seems to gain more trust for clusters with providers known to invest resources in quality, data transparent methodologies, and ethically validated, this also raised the importance of such issues towards acceptance. Trust was found to be the principle underlying all approaches relating product design and user behaviour, thus validating the proposed conceptual model.

6. Discussion and Implications

6.1 Interpretation of Key Findings

The findings of this study offer a comprehensive and an integrated insight on the formulation, functioning and integration of Green Digital Finance in to Malaysian financial system. The integration of GFEM analytic, heuristic and factual analyses emphasizes that credibility/efficacy of green digital finance products is deeply contingent on the user trust interaction with technology-capability-governance-appraisal. GFEM findings indicate significant variety among providers, with only a minority having high quality of sustainability statements and reflecting integrity. It means something — the green digital pillar — which was incubated in Malaysia may perhaps be uneven, with some sub-sectors (robo-advisors or digital banks) already racing at a gallop when viewed against their evidence-based and robust sustainability propositionsVS those still struggling due to firm capability constraints.

More negative findings from these differences can further be observed in the qualitative data. Time and again, experts said there is still not enough capacity, clarity around (taxonomies) or data infrastructure for sustainability features to

be consistently included. And precisely because of these limitations, it is what allowed so many purveyors to make really grand marketing-level statements but be utterly unable to back those claims with the kind of methodological rigor that would be required for a credible environmental claim." The interviews offer further explanation about the relationship between organisational governance and product quality as trusted products are largely manufactured by manufacturers with a governance infrastructure in ESG and Shariah at an early stage of product creation. This is in line with previous studies that focus on the governance quality as an important impact factor of companies' sustainability performance (Velte & Stawinoga, 2020).

These properties are highlighted even more in our experimental results when users perceive increased emphasis on simplicity and evidence, ethical watching and transparency. Products involving external assurance or dual ESG-Shariah assurance were found the most trusted and greater intention to adopt. This suggests that consumers, particularly in a dual banking system such as in Malaysia, consider signals that reduce information asymmetry and provide reassurances of ethical and environmental credibilities are of high significance. The mediations imply trust as a primary mechanism through which these cues of immediacy are converted into behavioral consequences. Collectively, these results support the theoretical prism of our study that potential adoption of sustainability at provider level establish a strong user trust by which significant use experiences in green digital finance products is stimulated.

6.2 Theoretical Implications

Theoretical contributions are evident as they add knowledge on how characteristics of sustainability are integrated, interpreted and appropriated in digital finance ecosystems. The research also contributes to the DOI model, by finding that attributes of innovation (eg observability, complexity and trialability) vary with digital finance products with environmental or ethical qualities. Sustainability cues are credibility devices that may condition how users interpret the value of novelty, particularly when details such as emissions methodologies or ESG scoring are opaque to most consumers. This also shows that not only validation cues but another perceived construct may be integrated into DOI model when applying the adoption behavior in digital context of sustainability.

The results also extend the theory of TOE in explaining how environmental and policy pressures interact with organizational readiness to affect sustainability adoption. The findings indicate that VCPT alignment alone is not sufficient to include high-quality sustainability capabilities, and the latter should be complemented with technological competences and embedded governance. Further, it suggests that the antecedent to TOE models "taxonom readiness" can be included—this concept captures an organisation's ability to translate at a high-level policy framework into a the design of operational products.

This study also contributes to IFS literature by revealing that the effect of Shariah governance on user trust in sustainability response is complementary with ESG governance. The finding that dual assurance yields highest trust and perceived impact scores reveals the Islamic ethical verification enhances credibility of environmental claims and builds user-confidence along other aspects different to those covered by traditional sustainability assurance mechanisms only. This double-validation process contributes towards a more comprehensive understanding about how ethical systems result in the adoption of financial innovations in Muslim majority markets.

6.3 Policy and Regulatory Implications

The findings are also of practical importance to the regulators, who can derive good governance practice from both perspectives on CCPT operationalization and FinTech governance. The dispersion of GFEM scores implies the need for policy-makers to potentially develop product-specific guidelines or standardized interpretation aids that assist FinTech providers adhere more consistently to CCPT principles. Regulators could also promote or reward the creation of audit-ready data pipelines to help future assurance. Greater clarity on what the CCPT classification implies, together with

templates for FinTech Sustainability Disclosure could eliminate inconsistencies surrounding interpretation amongst industry participants.

The paper also suggests regulatory assistance in developing sustainability assurance capacity. Assurance was mentioned by providers as too expensive or difficult to operationalize, while assurance became a key determinant of trust and use among users. Policy implications include the option of accrediting programs, an industry shared service platform or a subsidy to reduce the barriers of entry into assurance for small FinTech providers. Furthermore, the strong preference for dual ESG–Shariah assurance among users indicates Malaysia is in a conducive position to lead new schemes of integrated approaches towards joint validation of both environmental and Islamic ethical requirements within ESG. The latter would serve to augment Malaysia's position as a leader in Islamic sustainable finance and make it, the country, a regional hub for ethical digital finance innovations.

6.4 Industry and FinTech Players Implications

FinTech companies should construct robust data systems, make disclosure transparent and incorporate ESG and Shariah governance. Higher scores are related to earlier investments in data, organized transparency, and participation in governance. These activities create trust and make companies conspicuous in a crowd of competitors.

More obvious transparency of even the most basic sort—like simple taxonomy explanations—is enough to build trust from a user. Sustainability communication should be integrated into the actual design of products, not included only in marketing. They also indicate ESG and Shariah governance should not be isolated. ESG cannot work in vacuum. The verification get better and the ethic compatibility is stronger, and people have their belief to use.

6.5User and Consumer Education Implications

While environmentally-friendly attributes are of interest to end-users, they often do not directly have the expertise to assess environmental claims. Trust consequently plays a role in the uptake of green digital finance. This thereby requires transparency, external verification and ethical oversight. Assurance is perceived as an indicator not just of imitation but of good governance and actual environmental contribution. Accordingly, consumer education campaigns are necessary in order to explain what "sustainable" really is and how claims can be tested.

6.6 Broader Implications for the Sustainable Finance Ecosystem

The results demonstrate how digital finance can help countries meet their sustainability targets. Green Credible green features can mitigate user behaviors, and encourage responsible consumption, portfolio shift, and ecological lending.

Nevertheless, capability gaps, diversity taxonomy uncertain and preparation must be solved. Enhancing such ecosystem components will drive the FinTech innovation agenda towards congruence with Malaysia's climate and sustainability imperative, allowing FinTech to meet sustainable development needs.

7. Conclusion

This paper begins by examining Green Digital Finance in Malaysia. It looks at structural, institutional and behavioural determinants related to trustworthiness, transparency and uptake of environmental DF in products. Based on product inventory, interviews with experts and an experiment it is found that the incorporation of sustainability varies greatly amongst Malaysian FinTech companies. Many are too backward-looking, technologically immature and lacking in capacity and transparency to make a credible play at being green.

The evidence is that credibility relies on a stack of capabilities: robust data systems, transparent methods, independent assurance and integrated ESG–Shariah governance. These capabilities are related to CCPT alignment and increase GFEM scores. They also build user trust. Trust is also a mediating factor: Individuals do not only trust environmental claims, but perceive them as credible.

The policy implications are the more transparent product-level CCPT standards, taxonomy and assurance readiness training, as well as integrated ESG–Shariah screening. The improvement of these elements will increase the level of sustainability incorporations. For FinTech firms, a commitment to data, transparency and governance represent something of an approach mandated by regulation as well as differentiation that leads to trust.

For consumers and other purveyors of sustainable finance, the findings indicate a growing appetite for products designed ethically and with the environment in mind. Digital finance can mainstream sustainable choices and responsible consumption. But this relies on disciplined, clear communication of sustainability. In conclusion, this research contributes to a better theoretical and practical understanding of Green Digital Finance in Malaysia as well as the necessity for future studies focused on long-term impacts, guarantee systems and user contexts variation.

Declarations

Ethics statement: This study involved interviews and survey-based data collection with adult participants. Participation was voluntary, informed consent was obtained from all participants, and confidentiality and anonymity were maintained throughout the study.

Consent to participate:

Informed consent was obtained from all individual participants.

Consent to publish:

All authors consent to the publication of this manuscript.

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Author Contribution

M.S. conceptualized the study, designed the research framework and methodology, conducted the formal analysis, interpreted the findings, and wrote the original manuscript draft. H.S. substantially contributed to theoretical development, supervision, data interpretation, manuscript structuring, and critical revision of the paper. F.S. contributed significantly to methodology development, data analysis, validation, and manuscript revision. S.R.A. contributed to literature review, editing, and proofreading. All authors reviewed and approved the final version of the manuscript.

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