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Islamic finance development and FinTech innovation: pathways to financial inclusion in OIC and non-OIC countries

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Abstract

Purpose – This study aims to examine how Islamic finance development influences Islamic FinTech innovation and financial inclusion across 64 countries, while assessing the moderating role of internet penetration in these relationships.

Design/methodology/approach – The study draws on institutional theory and innovation diffusion theory and applies panel-corrected standard errors as the primary estimator, with feasible generalized least squares and two-stage least squares for robustness and endogeneity. The analysis tests five hypotheses using the Global Islamic Fintech Index, Islamic Finance Development Indicator and World Bank Global Findex data across the full sample and separately for Organization of Islamic Cooperation (OIC) and non-OIC countries.

Findings – Islamic finance development significantly fosters Islamic FinTech growth ($\beta = 0.508$, $p < 0.01$), with internet penetration as a critical enabler. Islamic FinTech increases account ownership ($\beta = 0.268$, $p < 0.01$) and digital transaction usage ($\beta = 0.375$, $p < 0.01$). However, the internet interaction effect is insignificant once governance is incorporated, suggesting threshold effects. Islamic finance development is negatively associated with financial inclusion ($\beta = -0.088$ and -0.172, $p < 0.05$), though this is concentrated in non-OIC countries and turns weakly positive in OIC contexts, potentially reflecting product complexity, market concentration and voluntary exclusion.

Originality/value – This study provides cross-country evidence linking Islamic finance development, FinTech innovation and financial inclusion. It shows that institutional maturity does not automatically translate into broader access to ethical financial services, challenging conventional assumptions and informing policy. It highlights the need for targeted interventions to translate institutional strength into inclusion through simplified Sharīʿah-compliant products, digital banking and grassroots Islamic FinTech.

Keywords Islamic FinTech, Islamic finance development, Financial inclusion, GIFT index, Financial technology, OIC countries, Financial development, Islamic banking and finance, Islamic financial institution, Financial system, Economic cooperation among Muslim countries, Islamic economic system

Paper type Research paper

1. Introduction

The global financial services industry is experiencing unprecedented transformation driven by the rapid advancement of financial technology (FinTech). Innovations such as mobile banking, digital wallets, peer-to-peer lending and blockchain-based platforms are reshaping how financial services are delivered, accessed and regulated. These developments have not

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only enhanced operational efficiency and customer orientation but have also opened new pathways for promoting financial inclusion, particularly in underserved and unbanked populations (Kishor *et al.*, 2025; Demirguc-Kunt *et al.*, 2022). For instance, according to the World Economic Forum's latest report, the financial inclusion role of FinTech is considerably more pronounced in emerging economies, where 70% of firms target micro, small and medium enterprises – compared to 49% in advanced markets – and where engagement with low-income and rural populations is roughly twice as high (Ferri de Camargo Paes *et al.*, 2025).

While FinTech is transforming the operational landscape of finance, Islamic finance has simultaneously emerged as a normative-based alternative to conventional finance. Being grounded in Sharī'ah principles, it promotes risk-sharing, asset-backed transactions and social justice (Alam *et al.*, 2019). These principles align closely with the objectives of sustainable development and make Islamic finance a potentially powerful framework for promoting financial inclusion. In particular, this is evident in Muslim-majority countries where religious beliefs often deter engagement with conventional financial institutions (Yorulmaz, 2016; Mohieldin *et al.*, 2011).

The COVID-19 pandemic accelerated Islamic financial institutions' adaptation of technology-driven solutions. This convergence of Islamic finance and digital innovation has given rise to Islamic FinTech, a rapidly growing sector that integrates Sharī'ah-compliant financial practices with cutting-edge technologies to enhance accessibility, transparency and efficiency (GIFT, 2025; Hassan *et al.*, 2022; El Amri *et al.*, 2021). Islamic FinTech platforms such as Wahed, Algbra and Funding Souq exemplify this trend, offering inclusive financial products tailored to the ethical and religious preferences of Muslim consumers (Islamic Financial Services Board, 2025). These further position Islamic FinTech not merely as a financial alternative but as a potential catalyst for equitable economic development. These characteristics are especially vital in Muslim-majority economies where demand for religion-aligned services remains high.

According to GIFT (2025), an index monitoring Global Islamic Fintech (GIFT) since 2021, the market is projected to expand from approximately US$161bn in transaction volumes in 2023/24 to nearly US$306bn by 2028. The surge is largely driven by a young and digitally savvy population in Muslim-majority countries, rising financial inclusion efforts and the strategic integration of technologies such as mobile platforms into Islamic financial institutions (Hassan *et al.*, 2022). With predominantly young, tech-savvy Muslim populations and growing digital connectivity, Organization of Islamic Cooperation (OIC) member states are well-positioned for Islamic FinTech innovation.

Despite its promise, the development of Islamic FinTech remains uneven across countries. For instance, while Malaysia, the UAE and Saudi Arabia have robust Islamic FinTech ecosystems, many Sub-Saharan African and MENA countries face limited digital infrastructure and low financial literacy (Islamic Fintech Dialogue Report, 2023; World Bank, 2020). In fact, only about 50% of adults in many OIC countries have access to a formal financial account, in contrast to a global average of 76% (Demirguc-Kunt *et al.*, 2022). This inclusion gap underscores a critical paradox. While Islamic finance promotes ethical oversight and risk-sharing, its institutional growth has not consistently translated into broader financial access.

Recent evidence suggests that digital transformation, particularly through Islamic FinTech, may offer a pathway to bridge this divide. Platforms leveraging blockchain, peer-to-peer financing, robo-advisory and mobile-based payment systems are increasingly delivering Sharī'ah-compliant services to underserved populations (Hassan *et al.*, 2022; Azman *et al.*, 2020). For instance, startups like Wahed Pay, Niyoftr and Sadad are expanding

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access to micro-savings, instant remittances and QR-code-based transactions, all structured under Sharī'ah principles. These innovations align with the wider vision of financial inclusion as a public good, one that resonates with Islamic socioeconomic ethics.

However, the mechanisms through which Islamic FinTech influences both the expansion of Islamic finance and the advancement of financial inclusion remain underexplored, particularly in a cross-national context. While existing studies have examined either the stability of Islamic banks (Khémiri *et al.*, 2024) or the general role of FinTech in financial inclusion (Kishor *et al.*, 2025), few have systematically analyzed how the maturity of the Islamic financial system, integrated with digital innovation, affects financial access and inclusion. Moreover, the moderating role of enabling factors such as internet penetration, a key infrastructural prerequisite for digital financial adoption, has received limited attention in the Islamic finance literature.

To address these gaps, this study investigates three interrelated dimensions:

(1) the impact of Islamic finance development on Islamic FinTech growth;

(2) the moderating role of internet penetration; and

(3) the effect of Islamic FinTech on financial inclusion.

Using data from 64 countries (43 OIC and 21 non-OIC) over 2021–2024, it uses panel-corrected standard errors (PCSEs) as the main estimator, with Feasible Generalized Least Squares (FGLSs) and two-stage least squares (2SLS) for robustness and endogeneity checks. The models account for cross-sectional dependence, heteroskedasticity and slope heterogeneity and include a governance index to isolate the role of institutional development. Results are estimated for the full sample and OIC and non-OIC subsamples.

This research contributes to the literature by providing standardized cross-country evidence linking Islamic finance development, FinTech innovation and financial inclusion, while controlling for institutional governance and examining OIC and non-OIC countries separately. The findings reveal both expected and paradoxical relationships that challenge conventional assumptions about financial sector development, offering important implications for policymakers designing inclusive Islamic FinTech strategies.

The rest of this paper is arranged as follows. Section 2 reviews the literature and theoretical framework to extract key concepts and reveal empirical evidence. Section 3 presents the data and methodology used. Section 4 reports and discusses empirical results. Finally, Section 5 concludes with policy implications and suggestions for future research.

2. Literature review

2.1 Theoretical framework

This study is based on two interrelated theoretical perspectives: institutional theory and innovation diffusion theory (IDT). These two theories provide a solid analytical framework for understanding how macro-level structures and micro-level adoption behaviors interact in the emergence and spread of Islamic FinTech.

2.1.1 Institutional theory. Institutional theory explores how organizations are influenced by the rules, norms and beliefs of the institutional environments in which they operate. Scott (1995) and Scott (2014) developed three pillars of institutions: regulative, normative and cultural-cognitive. In the context of Islamic FinTech, the regulative pillar involves legal frameworks, central bank policies and Sharī'ah governance standards that legitimize and structure digital financial activities (Louafi, 2025; Yasardin *et al.*, 2025). The normative pillar reflects societal expectations regarding ethical conduct, trust in religious compliance and corporate social responsibility (CSR), all of which influence consumer preferences for

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Sharī'ah-compliant services (Khémiri *et al.*, 2024). Finally, the cultural-cognitive pillar involves shared understandings of what constitutes permissible "halal" finance, digital literacy and perceived ease of use as crucial components of user adoption (Najib, 2024; Ali *et al.*, 2021). These institutional dimensions are essential in explaining why some countries develop vibrant Islamic FinTech ecosystems while others fall behind. For example, Malaysia and the UAE exemplify this through regulatory sandboxes and Sharī'ah advisory councils (Islamic Fintech Dialogue Report, 2023), while many low-income OIC countries lack such frameworks.

2.1.2 Innovation diffusion theory. This theory explains how innovations spread across populations and geographies. The theory developed by Rogers (1995) identified five key attributes that influence adoption: relative advantage, compatibility, complexity, trialability and observability. In the case of Islamic FinTech, this means that platforms are more likely to succeed if they offer clear benefits over conventional alternatives (relative advantage), align with religious beliefs of users (compatibility), are easy to use (low complexity), allow for small-scale testing (trialability) and demonstrate visible success stories (observability). Mobile zakat apps succeed through religious compatibility, low costs and transparency, though rural communities may resist because of complexity concerns or Sharī'ah doubts (Kaya, 2023).

These theories guide the selection of variables and interpretation of results. While the Islamic Finance Development Indicator (IFDI) captures the strength of regulative and normative institutions, GIFT reflects the stage of technological innovation, and financial inclusion represents the outcome of successful diffusion. Internet penetration acts as a key enabler, reducing complexity and enhancing connectivity by accelerating the diffusion process.

2.2 Empirical studies

2.2.1 Islamic finance development and FinTech innovation. The relationship between Islamic finance development and FinTech innovation has emerged as a critical area of scholarly inquiry. In particular, there is a growing recognition that established Islamic finance ecosystems provide essential foundations for technological innovation. Alam *et al.* (2019) argue that Islamic finance development creates demand for scalable, technology-enabled solutions that can deliver Sharī'ah-compliant services more efficiently and accessibly than traditional banking models.

Empirically supporting this perspective, Rabbani *et al.* (2020) show that countries with more developed Islamic banking sectors exhibit higher levels of Islamic FinTech innovation, measured by the number of Islamic FinTech startups, funding volumes and product diversity. Similarly, Naifar (2020) finds that Islamic finance development positively influences the adoption of financial technologies within Islamic financial institutions, suggesting that institutional capabilities developed in traditional Islamic finance translate into technological innovation capacity. However, the relationship is not uniformly positive across all contexts. Abdeljawad *et al.* (2022) highlight significant technological and institutional constraints faced by Islamic financial institutions, particularly in low-income OIC countries where limited digital infrastructure and regulatory uncertainty hinder FinTech development. These findings suggest that the relationship between Islamic finance development and FinTech innovation is moderated by broader institutional and infrastructural conditions.

The role of digital infrastructure as a moderating factor has received particular attention in recent literature. Hassan *et al.* (2022) emphasize that even countries with well-developed Islamic finance sectors may struggle to translate this development into FinTech innovation without adequate digital infrastructure, including internet connectivity, mobile network

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coverage and digital payment systems. This perspective supports Arner *et al.* (2020), who argue that FinTech innovation requires the convergence of financial sector development and digital infrastructure capabilities.

2.2.2 Islamic FinTech and financial inclusion. The potential of Islamic FinTech to promote financial inclusion has generated considerable scholarly interest, with researchers examining both the theoretical mechanisms and empirical evidence for this relationship. The theoretical case for Islamic FinTech as a driver of financial inclusion rests on several key arguments. Islamic FinTech addresses religious barriers through Sharī'ah-compliant alternatives (Mohieldin *et al.*, 2011), reduces costs via digital delivery (Shaikh *et al.*, 2017) and provides entry-level services that gradually integrate users into the formal financial system (Hudaefi, 2020).

Empirical evidence for these theoretical standpoints is mixed but generally supportive. Azman *et al.* (2020) find that Islamic FinTech utilization among micro-entrepreneurs in Malaysia is associated with improved access to financing and enhanced business sustainability. Similarly, Atif *et al.* (2021) contend that Islamic FinTech has evolved into a viable instrument for addressing financial challenges consistent with sustainability principles. Abdu *et al.* (2018) also underscore the necessity of Islamic banking as a vehicle for broadening financial access in Sub-Saharan countries.

However, the relationship between Islamic FinTech and financial inclusion is not uniformly positive across all contexts and measures. Hudaefi (2020) notes that while Islamic FinTech can expand access to basic financial services, its impact on deeper forms of financial inclusion, such as access to credit and investment opportunities, depends on wider ecosystem factors including regulatory frameworks, digital literacy and economic conditions. The complexity of this relationship is further highlighted by research on the differential impacts of Islamic finance development and Islamic FinTech on financial inclusion. While Islamic FinTech appears to promote inclusion through digital channels, some studies suggest that traditional Islamic finance development may not automatically translate into broader financial inclusion. For example, Khémiri *et al.* (2024) identified a nonlinear, inverted U-shaped relationship between financial inclusion and Islamic banking stability in GCC nations, while Suseno and Fitriyani (2019) found a negative impact of Islamic finance development on financial inclusion in OIC countries.

2.2.3 Moderating factors and contextual influences. Recent literature has increasingly recognized that the relationships between Islamic finance development, FinTech innovation and financial inclusion are moderated by various contextual factors. Digital infrastructure emerges as a particularly important moderating variable, with several studies demonstrating that the benefits of both Islamic finance development and FinTech innovation are amplified in environments with robust internet connectivity and mobile network coverage (Demirguc-Kunt *et al.*, 2018; Mention, 2019).

Macroeconomic conditions also play important moderating roles. Claessens *et al.* (2018) demonstrate that FinTech development is sensitive to economic volatility. These findings are particularly relevant for many OIC countries that experience significant macroeconomic volatility. Regulatory frameworks represent another critical moderating factor. The Islamic Fintech Dialogue Report (2023) identifies regulatory uncertainty as a major barrier to Islamic FinTech development, particularly in countries lacking clear guidelines for Sharī'ah-compliant FinTech products and services. Conversely, countries with comprehensive regulatory frameworks for both Islamic finance and FinTech, such as Malaysia and the UAE, demonstrate more robust ecosystem development. More broadly, the quality of institutional governance, such as regulatory effectiveness, rule of law and control of corruption, shapes the environment in which Islamic finance and FinTech operate.

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Despite growing interest, significant gaps remain. Most studies focus on single countries, few examine simultaneous relationships using cross-country data, and digital infrastructure's moderating role remains underexplored. This study addresses these gaps by providing cross-country empirical analysis of Islamic FinTech ecosystem development and its dual relationship with Islamic finance development and financial inclusion. Using panel data from 64 countries over the period 2021–2024, the study examines both the determinants of Islamic FinTech development and its impacts on financial inclusion outcomes. The analysis explicitly considers the moderating role of digital infrastructure and controls for various macroeconomic and institutional factors that may influence these relationships. The analysis further accounts for institutional governance and examines OIC and non-OIC countries separately, addressing the structural heterogeneity that prior single-country studies could not capture.

This study contributes by:

- examining institutional maturity (measured by IFDI) and FinTech innovation (GIFT) interdependence, challenging assumptions about automatic inclusive transformation;
- highlighting digital infrastructure's mediating role; and
- revealing the paradoxical IFDI-inclusion disconnect with policy implications. It, thus, offers actionable guidance for fostering inclusive Sharī'ah-compliant ecosystems.

Based on the theoretical framework and empirical literature reviewed, this study tests the following hypotheses:

H1. Islamic finance development has a positive effect on Islamic FinTech growth.

H2. Internet penetration positively moderates the relationship between Islamic finance development and Islamic FinTech growth.

H3. Islamic FinTech has a positive effect on financial inclusion (measured by account ownership and digital transaction usage).

H4. Islamic finance development has a positive effect on financial inclusion.

H5. Internet penetration has a positive effect on financial inclusion.

3. Data and methodology

3.1 Data

This study uses a panel data set of 43 OIC and 21 non-OIC countries, a total of 64 countries, covering the period 2021–2024. The sample is drawn from countries included in the GIFT index reports, which have been published annually since 2021 and provide the only standardized cross-country measure of Islamic FinTech ecosystem strength. The analysis period captures recent Islamic FinTech developments, including post-COVID digital transformation. The sample includes 64 countries, both OIC and non-OIC, spanning wide variation in Islamic finance development, digital infrastructure, regulation, income levels and financial inclusion, providing the heterogeneity needed for identification. The full country list is provided in Appendix.

The analysis includes three core variable categories: Islamic FinTech (GIFT index), Islamic finance development (IFDI) and financial inclusion. The GIFT index captures regulatory, investment and digital ecosystem dynamics (GIFT, 2025), while IFDI reflects institutional depth,

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governance, awareness and social contributions (Islamic Financial Services Board, 2025). Financial inclusion is measured using Global Findex indicators – account ownership and digital transactions among adults (Demirguc-Kunt *et al.*, 2022). Macroeconomic controls (e.g. GDP growth, inflation, trade openness, population growth, internet use, unemployment and governance) are drawn from the World Development Indicators.

Table 1 provides the complete variable definitions and summary statistics. The descriptive statistics reveal significant cross-country and temporal variation, justifying panel data techniques to capture both dimensions.

3.2 Model specification and estimation strategy

To empirically test the hypothesis derived from the theoretical framework and literature review, three models are specified:

Model 1 examines the impact of Islamic finance development on Islamic FinTech:

$$GIFT_{it} = \beta_0 + \beta_1 IFDI_{it} + \beta_2 \text{INTERNET}_{it} + \beta_3 \text{GDPPCG}_{it} + \beta_4 \text{INF}_{it} + \beta_5 \text{TRADE_OPEN}_{it} + \beta_6 \text{POP}_{it} + \beta_7 \text{UNEMP}_{it} + \beta_8 \text{GOV}_{it} + \varepsilon_{it}$$

Model 2 introduces interaction terms to test internet penetration's moderating role:

Table 1. Variable definitions and summary statistics

Variable	Description	Mean	Standard deviation	Min.	Max.	Expected
GIFT	Global Islamic Fintech index (0–100)	26.091	17.773	0.700	87.0	
ACCOUNT	Account ownership (% age 15%)	63.665	27.930	9.654	99.977	
DIGITAL_TRANSAC	Made or received digital transactions (% age 15%)	57.040	29.597	7.881	99.481	
IFDI	Islamic Finance Development Indicator (0–200)	19.354	23.246	0.070	143.680	+
GDPPG	GDP per capita growth (annual %)	2.018	5.341	−28.271	33.769	+
INF	Inflation (CPI, annual percentage)	18.357	59.484	−6.601	660.0	−
TRADE	Trade (% of GDP)	87.133	73.877	0.280	412.177	+
POP	Population growth rate (annual %)	1.447	1.666	−10.927	7.323	+
INTERNET	Individuals using the internet (% of population)	72.272	25.926	12.600	100.0	+
UNEMP	Unemployment (% of total labor force)	7.761	7.317	0.126	67.200	−

Note(s): + and − signs indicate expected sign based on literature
Source(s): Authors' own work

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$$GIFT_{it} = \beta_0 + \beta_1 IFDI_{it} + \beta_2 \text{INTERNET}_{it} + \beta_3 (\text{IFDI*INTERNET})_{it} + \beta_4 \text{GDPPCG}_{it} + \beta_5 \text{INF}_{it} + \beta_6 \text{TRADE_OPEN}_{it} + \beta_7 \text{POP}_{it} + \beta_8 \text{UNEMP}_{it} + \beta_9 \text{GOV}_{it} + \varepsilon_{it}$$

Model 3 examines how both Islamic FinTech and Islamic finance development affect financial inclusion:

$$ACCOUNT_{it} = \beta_0 + \beta_1 GIFT_{it} + \beta_2 IFDI_{it} + \beta_3 \text{INTERNET}_{it} + \beta_4 \text{GDPPCG}_{it} + \beta_5 \text{INF}_{it} + \beta_6 \text{TRADE_OPEN}_{it} + \beta_7 \text{POP}_{it} + \beta_8 \text{UNEMP}_{it} + \beta_9 \text{GOV}_{it} + \varepsilon_{it}$$

$$DIGITAL_TRANSAC_{it} = \beta_0 + \beta_1 GIFT_{it} + \beta_2 IFDI_{it} + \beta_3 \text{INTERNET}_{it} + \beta_4 \text{GDPPCG}_{it} + \beta_5 \text{INF}_{it} + \beta_6 \text{TRADE_OPEN}_{it} + \beta_7 \text{POP}_{it} + \beta_8 \text{UNEMP}_{it} + \beta_9 \text{GOV}_{it} + \varepsilon_{it}$$

where i indexes countries ($i = 1, \ldots, 64$) and t indexes years ($t = 2021, \ldots, 2024$). The error term ε_{it} captures unobserved factors. All models include relevant macroeconomic and demographic controls to minimize omitted variable bias and isolate the effects of primary interest. Model 2 raises potential multicollinearity concerns, as interaction terms are inherently correlated with their constituent variables (Dalal and Zickar, 2012; Aiken and West, 1991). Therefore, mean-centering was used for both IFDI and INTERNET prior to constructing the interaction (Disatnik and Sivan, 2016; Iacobucci *et al.*, 2017), which addresses collinearity without affecting coefficient interpretation (Echambadi and Hess, 2007). Variance inflation factor (VIF) values for all variables remain below the threshold of 5 (Hair *et al.*, 2010).

3.2.1 Diagnostic tests. Prior to estimation, diagnostic tests identify the appropriate econometric techniques. Pesaran's (2004) cross-sectional dependence (CD) test examines whether countries exhibit contemporaneous correlation because of common global shocks (e.g. COVID-19's acceleration of digital finance), regional policy spillovers through organizations like the Islamic Financial Services Board and shared technological trends. Ignoring such dependence produces biased standard errors. Slope homogeneity tests (Blomquist and Westerlund, 2013; Pesaran and Yamagata, 2008) test whether variable relationships are uniform across countries or vary systematically, given diverse institutional environments, regulatory frameworks and digital infrastructure quality. Imposing homogeneity when slopes vary produces inconsistent parameter estimates. The presence of CD and slope heterogeneity, both confirmed in the data, rules out standard fixed effects or random effects estimators, which assume independence and homogeneity, requiring an approach that explicitly accounts for these features.

3.2.2 Estimation approach. The study adopts PCSE estimation as the primary approach, following Beck and Katz (1995). PCSE is well-suited for panels with large cross-sections ($n = 64$) and short time dimensions ($T = 4$), correcting for contemporaneous correlation, panel-specific heteroskedasticity and first-order autocorrelation simultaneously. PCSE is appropriate for panels exhibiting these features regardless of the N–T ratio (Reed and Ye, 2011; Beck and Katz, 1995), with recent applications confirming its effectiveness for similar structures (Saeed *et al.*, 2024; Zidi and Hamdi, 2024; Ikpesu *et al.*, 2019). The study complements PCSE with FGLS for a robustness check, as FGLS handles heteroskedasticity and autocorrelation through different technical mechanisms. Consistency across both

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estimators strengthens confidence that findings reflect genuine relationships, a dual estimation strategy now standard in panel studies (Saeed *et al.*, 2024). To address potential reverse causality between Islamic finance development and FinTech, the analysis uses 2SLS using the first lag as an instrument. All models are estimated for the full sample, OIC and non-OIC subsamples to assess heterogeneity, with an additional post-2021 sensitivity check.

4. Results analysis and discussions

4.1 Descriptive statistics

Table 1 presents variable definitions and summary statistics. The GIFT Index shows a mean of 26.091 (SD = 17.773, range: 0.700–87.0), indicating large heterogeneity in Islamic FinTech ecosystem development. Malaysia, UAE and Saudi Arabia occupy the upper bound, while several Sub-Saharan African nations are at the lower end, reflecting diversity in regulatory frameworks and digital infrastructure.

Financial inclusion indicators show relatively high averages but considerable cross-country variation. Account ownership (ACCOUNT) averages 63.665 (SD = 27.930), while digital transaction usage (DIGITAL_TRANSAC) shows a mean of 57.040 (SD = 29.597). Many OIC countries fall short of the 76% global average (Demirguc-Kunt *et al.*, 2022), highlighting why financial inclusion remains a central policy challenge.

The IFDI presents a mean of 19.354 (SD = 23.246), suggesting significant cross-country differences in Islamic financial system maturity. Among control variables, internet penetration averages 72.272 (SD = 25.926), while inflation shows extreme variation (mean = 18.357, SD = 59.484, maximum = 660.0), indicating economies experiencing severe macroeconomic turbulence. Unemployment exhibits considerable dispersion (mean = 7.761, SD = 7.317), revealing diverse labor market conditions that may constrain FinTech innovation and digital financial service adoption. These statistics reveal significant variation, supporting panel data techniques to analyze Islamic FinTech determinants and financial inclusion impacts.

4.2 Governance index construction

To incorporate institutional quality, we construct a composite governance index (GOV) by applying principal component analysis (PCA) to the six Worldwide Governance Indicators: control of corruption, government effectiveness, political stability, regulatory quality, rule of law and voice and accountability (Kaufmann *et al.*, 2011). Given the strong correlation among these dimensions, PCA is used to effectively condense their shared variance into a single, robust metric (Polat, 2020). Following the Kaiser criterion (Goretzko and Bühner, 2022), we retain only the first principal component, which yields an eigenvalue of 5.314 and explains 88.2% of the total variance (Table 2). A Kaiser–Meyer–Olkin (KMO) statistic of 0.845 confirms robust sampling adequacy (Kaiser, 1974). With positive, even loadings (0.36–0.43) across all dimensions, GOV provides a coherent proxy for governance quality and is included in all subsequent models.

4.3 Correlation and multicollinearity assessment

Figure 1 presents the correlation heatmaps under the two analytical frameworks. Panel A shows a strong positive correlation between Islamic FinTech (GIFT) and Islamic finance development (IFDI) (0.749, $p < 0.01$), supporting the theory that mature financial ecosystems foster technological innovation. Digital infrastructure and governance also serve as foundational enablers, with GIFT correlating positively with internet penetration (0.476, $p < 0.01$) (Arner *et al.*, 2020; Demirguc-Kunt *et al.*, 2018) and governance (GOV) (0.474, $p < 0.01$). Conversely, the negative correlations between GIFT and both inflation (−0.175,

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Table 2. Principal component analysis of governance indicators

Component	Eigenvalue	Variance %	Cumulative %
PC1	5.314	88.22	88.22
PC2	0.412	6.85	95.07
PC3	0.201	3.33	98.40
PC4	0.048	0.79	99.19
PC5	0.034	0.57	99.76
PC6	0.014	0.24	100.00

Note(s): KMO = 0.845. PC1 retained as the governance index (GOV); WGI loadings range from 0.36 to 0.43, all positive
Source(s): Authors' own work

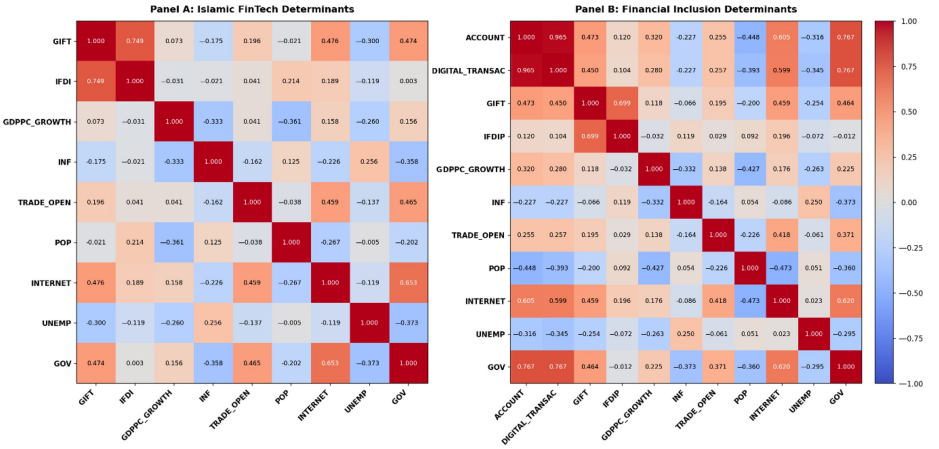


Figure 1. Correlation heatmap results

$p < 0.01$) and unemployment (−0.300, $p < 0.01$) suggest that macroeconomic instability and labor market distress constrain FinTech growth (Claessens *et al.*, 2018).

In Panel B, GIFT moderately correlates with financial inclusion measures (ACCOUNT: 0.473, $p < 0.01$; DIGITAL_TRANSAC: 0.450, $p < 0.01$), signaling Islamic FinTech's potential role in expanding financial access. However, IFDI exhibits weak correlations with these inclusion indicators (ACCOUNT: 0.120; DIGITAL_TRANSAC: 0.104), hinting at a disconnect between institutional maturity and grassroots financial access. Finally, internet penetration and governance strongly enable financial inclusion, exhibiting robust positive correlations with both ACCOUNT (0.605, $p < 0.01$ and 0.767, $p < 0.01$) and DIGITAL_TRANSAC (0.599, $p < 0.01$ and 0.767, $p < 0.01$), respectively. The correlation analysis highlights the key role of Islamic finance development in driving Islamic FinTech, while also pointing to a potential disconnect between institutional maturity and financial inclusion and a pathway to translating Islamic FinTech growth into broader financial inclusion.

Given the inclusion of interaction terms in Model 2, we address multicollinearity concerns through mean-centering procedures. Table 3 illustrates the necessity and

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Table 3. Correlation matrices before and after mean-centering

Panel A: Original variables	IFDI	INTERNET	IFDI_INTERNET
IFDI	1.0000		
INTERNET	0.1896	1.0000	
IFDI_INTERNET	0.9526	0.3796	1.0000
Panel B: Mean-centered variables	IFDI_C	INTERNET_C	IFDI_INTERNET_C
IFDI_C	1.0000		
INTERNET_C	0.1896	1.0000	
IFDI_INTERNET_C	0.5374	0.0240	1.0000

Source(s): Authors' own work

effectiveness of this approach. Panel A reveals that the original interaction term (IFDI_INTERNET) shows problematic correlation with IFDI (r = 0.953), confirming severe structural multicollinearity that would inflate variance estimates and destabilize coefficient interpretation. Panel B shows that mean-centering significantly reduces this correlation to 0.537, effectively mitigating the collinearity problem while preserving the substantive meaning of interaction effects. This transformation follows established best practices in moderated regression analysis (Dalal and Zickar, 2012; Aiken and West, 1991).

Table 4 presents VIFs for the mean-centered specification, providing definitive confirmation that multicollinearity does not compromise parameter estimates. The interaction term (IFDI_INTERNET) exhibits a VIF of only 1.557, well below even the conservative thresholds. All variables fall comfortably within acceptable bounds, with the mean VIF of 1.614 indicating model stability. These diagnostics justify confidence in the reliability of coefficient estimates reported in subsequent regression analysis.

4.4 Panel data diagnostics

Before proceeding with estimation, cross-sectional dependency and slope homogeneity tests were conducted to identify data structure properties and guide methodological choices. Pesaran's (2004) CD test, presented in Table 5, shows a statistic of 10.844 (p < 0.001),

Table 4. Variance inflation factors (VIF)

Variable	VIF	1/VIF	Assessment
IFDI_INTERNET	1.557	0.642	No multicollinearity concern
IFDI	1.476	0.677	No multicollinearity concern
INTERNET	2.214	0.452	No multicollinearity concern
POP	1.473	0.679	No multicollinearity concern
TRADE_OPEN	1.370	0.730	No multicollinearity concern
GDPPC_GROWTH	1.356	0.738	No multicollinearity concern
UNEMP	1.354	0.739	No multicollinearity concern
INF	1.295	0.772	No multicollinearity concern
GOV	2.429	0.412	No multicollinearity concern
Mean VIF	1.614		

Note(s): VIF values below 3 suggest no multicollinearity concern (Hair *et al.*, 2010)
Source(s): Authors' own work

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Table 5. Pesaran's cross-sectional dependence test results

Test	Test statistic	*p*-value	Avg.	Conclusion
Pesaran's CD test (abs)	10.844	0.0000	0.557	Reject *H0*: cross-sectional independence

Note(s): Average absolute correlation value of (0.539) indicates a moderate to strong relationship across countries
Source(s): Authors' own work

decisively rejecting the null hypothesis of cross-sectional independence. This finding confirms significant interdependencies among countries, likely driven by common global shocks such as the acceleration of digital finance driven by the COVID-19 pandemic; regional policy coordination among OIC member states; and shared technological trends affecting Islamic finance ecosystems. Such dependence is particularly likely to occur given the Islamic Financial Services Board's standard-setting role and coordinated regulatory initiatives documented in the Islamic Fintech Dialogue Report (2023).

As reported in Table 6, Slope homogeneity tests provide further critical information about data structure. Both the Pesaran and Yamagata (2008) test ($\Delta = -8.653$, $p < 0.001$) and Blomquist and Westerlund (2013) heteroskedasticity-robust variant ($\Delta\text{HAC} = -8.394$, $p < 0.001$) strongly reject slope homogeneity. These results confirm that the relationships between Islamic FinTech adoption and its determinants vary systematically across countries. This confirms heterogeneous institutional environments, regulatory frameworks, digital infrastructure quality and socioeconomic contexts.

The joint presence of CD and slope heterogeneity justifies our adoption of PCSE estimation as proposed by Beck and Katz (1995). This approach explicitly accounts for simultaneous correlation across panels, panel-specific heteroskedasticity and autocorrelation within panels. Recent applications in cross-country financial studies prove PCSE's effectiveness in addressing precisely these econometric challenges (Saeed *et al.*, 2024; Zidi and Hamdi, 2024; Ayuba *et al.*, 2023; Ikpesu *et al.*, 2019).

4.5 Main regression results: Islamic FinTech determinants

Table 7 presents PCSE estimation results examining Islamic FinTech determinants through both a baseline specification (Model 1) and an interaction model testing moderating effects (Model 2), each across the full, OIC and non-OIC samples.

In Model 1, Islamic finance development (IFDI) exerts a significant positive effect on Islamic FinTech (GIFT) in every sample. Specifically, the coefficients indicate robust impacts for the full (0.508, $p < 0.01$), OIC (0.605, $p < 0.01$) and non-OIC (0.523, $p < 0.01$), providing strong support for *H1*. The effect is particularly strongest among OIC countries,

Table 6. Slope homogeneity test results

Test	Test statistic	Value	Conclusion
Pesaran and Yamagata (2008)	Delta	−8.653***	Reject *H0*: slope coefficients are homogeneous
Blomquist and Westerlund (2013)	$\text{Delta}_{\text{HAC}}$	−8.394***	Reject *H0*: slope coefficients are homogeneous

Note(s): *** represents statistical significance at 1%. The adjusted delta statistics could not be computed because of the limited time dimension. While *Delta* represents the simple slope homogeneity tests, the $Delta_{HAC}$ represents the heteroscedasticity versions of simple slope homogeneity
Source(s): Authors' own work

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Table 7. Main regression results: Islamic FinTech determinants

Variable	Model 1: IFDI → GIFT			Model 2: Interaction		
	Full	OIC	Non-OIC	Full	OIC	Non-OIC
Islamic finance development (IFDI)	0.508*** (0.050)	0.605*** (0.064)	0.523*** (0.082)	0.444*** (0.112)	0.554*** (0.111)	−0.083 (0.104)
Internet penetration (INTERNET)	0.213*** (0.025)	0.238*** (0.021)	0.345*** (0.041)	−0.036 (0.064)	0.017 (0.054)	−0.307*** (0.115)
IFDI × internet (IFDI_INTERNET)	–	–	–	0.001 (0.001)	0.001 (0.001)	−0.004 (0.006)
GDP per capita growth (GDPPCG)	0.138** (0.054)	0.121* (0.066)	0.325* (0.178)	0.373** (0.168)	0.219 (0.162)	0.363 (0.273)
Inflation (INF)	0.022** (0.009)	−0.008(0.009)	0.024(0.127)	0.013 (0.014)	0.004 (0.009)	0.110 (0.179)
Trade openness (TRADE_OPEN)	−0.016*** (0.002)	−0.066*** (0.021)	−0.001 (0.010)	0.041* (0.022)	0.068 (0.051)	0.020 (0.015)
Population growth (POP)	0.010 (0.353)	−0.021(0.430)	0.846* (0.483)	0.106 (0.672)	0.075 (0.843)	0.441 (0.417)
Unemployment (UNEMP)	−0.002 (0.046)	−0.107(0.107)	−0.429*** (0.062)	0.655** (0.299)	0.372 (0.252)	0.524* (0.286)
Governance (GOV)	2.055*** (0.415)	0.135(0.602)	0.244 (0.570)	3.976*** (0.619)	1.384** (0.582)	5.803*** (0.928)
Constant	0.685 (0.585)	−0.166(0.560)	−0.998 (0.788)	6.091** (2.678)	8.500** (3.945)	2.081* (1.145)
Observations	256	172	84	256	172	84

Note(s): Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Models 1 and 2: dependent variable = GIFT. Model 2 uses mean-centered IFDI and internet penetration

Source(s): Authors' own work

where Islamic finance provides the foundational infrastructure and ethical framework upon which Islamic FinTech innovations thrive (Rabbani *et al.*, 2020; Alam *et al.*, 2019). It is also consistent with institutional theory, as mature ecosystems provide regulatory clarity and specialized Sharī'ah expertise essential for FinTech startups (Hassan *et al.*, 2022). This institutional depth explains why Malaysia, the UAE and Bahrain have emerged as Islamic FinTech hubs, as they offer the regulatory clarity and expertise that enable scalable innovation. As a result, FinTech startups offering services such as blockchain-enabled zakat systems and digital Islamic investment platforms are increasingly enhancing transparency, inclusion and ethical control within the boundaries of Islamic finance principles (Ayodeji, 2024; IsDB, 2020; Gomber *et al.*, 2018). Internet penetration is also a consistent and vital enabler across all samples (0.213–0.345, $p < 0.01$), confirming that digital connectivity serves as essential infrastructure for FinTech adoption. This finding resonates with Demirguc-Kunt *et al.*'s (2018) emphasis that mobile and internet access constitute prerequisites for digital financial service delivery. Additionally, institutional governance (GOV) is positive and significant in the full sample (2.055, $p < 0.01$), highlighting that broad institutional quality independently supports ecosystem development alongside fundamental digital infrastructure.

Model 2 expands this analysis by introducing the interaction between Islamic finance development and internet penetration (IFDI_INTERNET). While the main effect of IFDI remains resilient, positive and significant in the full and OIC samples, the interaction term is economically marginal and statistically insignificant across all specifications once governance is controlled (−0.004–0.001, $p > 0.05$). With mean-centered variables, main effects represent conditional relationships at average moderator levels (Aiken and West, 1991). This finding rejects *H2*, which posited a positive moderating effect. Rather than internet penetration universally amplifying the finance–FinTech link, the connectivity variable exhibits a saturation dynamic. Once a necessary baseline of digital infrastructure is in place, considering that five Gulf states already exceed 99% internet penetration (State of the Global Islamic Economy, 2025), additional connectivity ceases to be the binding constraint. Instead, as shown by the strengthened significance of GOV in Model 2, primary regulatory capacity and Sharī'ah governance quality become the operative factors. This is consistent with evidence that FinTech operates differently within the institutional matrix of emerging OIC economies, suggesting that qualitative regulatory frameworks supersede technological expansion once fundamental digital access is achieved (Rabbani and Kiran, 2025).

4.6 Impact of Islamic FinTech and Islamic finance development on financial inclusion

Table 8 presents the impact of Islamic FinTech and Islamic finance development on financial inclusion outcomes across the full, OIC and non-OIC samples.

Islamic FinTech (GIFT) exerts a robust, positive effect on both outcomes across all specifications (account ownership: 2.150–0.310; digital transaction: 0.284–0.472, all $p < 0.01$), confirming *H3*. This highlights the transformative role of Islamic FinTech as a catalyst for financial inclusion, which extends access to underserved populations through mobile banking platforms, digital payment systems and Sharī'ah-compliant micro-investment vehicles (Azman *et al.*, 2020; Hudaefi, 2020). Leading Islamic FinTech platforms exemplify this dynamic: institutions such as Wahed, Algbra, EasyPaisa and Funding Souq, ranked among the top 30 institutions in the Islamic finance sector, have successfully reached unbanked populations by using mobile technology to extend services without requiring physical branch infrastructure (GIFT, 2025). These innovations bypass traditional intermediaries, simultaneously reducing transaction costs and alleviating the religious

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Table 8. Main regression results: determinants of financial inclusion

Variable	Account ownership			Digital transactions		
	Full	OIC	Non-OIC	Full	OIC	Non-OIC
Islamic FinTech (GIFT)	0.268*** (0.095)	0.310*** (0.091)	2.150*** (0.276)	0.375*** (0.036)	0.284*** (0.044)	0.472*** (0.040)
Islamic finance development (IFDI)	−0.088** (0.042)	0.072** (0.028)	−0.975** (0.385)	−0.172*** (0.010)	0.076** (0.029)	−0.622*** (0.064)
Internet penetration (INTERNET)	0.533*** (0.084)	0.564*** (0.030)	0.176 (0.141)	0.552*** (0.076)	0.437*** (0.027)	0.819*** (0.031)
GDP per capita growth (GDPPCG)	2.097*** (0.287)	0.142 (0.116)	−0.316 (0.235)	1.285*** (0.313)	0.452** (0.170)	−0.333 (0.299)
Inflation (INF)	0.454*** (0.084)	0.127 (0.104)	1.556 (2.192)	0.257** (0.099)	0.175* (0.092)	0.740* (0.373)
Trade openness (TRADE_OPEN)	−0.038*** (0.005)	0.001 (0.028)	−0.029** (0.013)	−0.015 (0.013)	0.007 (0.015)	−0.023*** (0.004)
Population growth (POP)	6.117*** (0.707)	0.378 (0.292)	1.954 (1.321)	4.344*** (0.593)	4.402*** (0.807)	−1.431 (1.196)
Unemployment (UNEMP)	−0.248 (0.240)	−0.802*** (0.058)	2.444*** (0.616)	−0.417** (0.177)	−1.126*** (0.074)	0.246*** (0.035)
Governance (GOV)	6.068*** (0.716)	−0.826* (0.442)	−0.122 (2.116)	6.047*** (0.750)	−1.213 (0.738)	1.648*** (0.510)
Constant	3.196 (2.317)	2.720 (2.054)	3.705 (3.725)	1.848 (2.400)	1.597 (1.648)	0.365 (0.677)
Observations	110	70	40	110	70	40

Note(s): Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Source(s): Authors' own work

barriers that previously deterred Muslim populations from conventional financial engagement while adhering to Islamic principles (Islamic Financial Services Board, 2025; Shaikh *et al.*, 2017).

Despite these gains, a central paradox emerges concerning Islamic finance development (IFDI). In the full sample, IFDI is negatively and significantly associated with both account ownership (−0.088, $p < 0.05$) and digital transactions (−0.172, $p < 0.01$), rejecting *H4*. This paradox remains robust after accounting for institutional quality (GOV), indicating that the observed relationship is not simply driven by governance differences. The subsample analysis reveals important heterogeneity in this dynamic. The negative association is concentrated in non-OIC countries (account ownership: −0.975, $p < 0.05$; digital transaction: −0.622, $p < 0.01$), where Islamic finance often functions as a small, elite-oriented niche. Among OIC countries, on the other hand, the coefficient is weakly positive (account ownership: 0.072; digital transaction: 0.076, both $p < 0.05$), indicating that where Islamic finance operates as a mainstream system, institutional development does not undermine inclusion and may modestly support it. This counterintuitive finding suggests that while institutional maturity in Islamic finance facilitates FinTech growth, it may moderately enhance financial access and may even be associated with reduced inclusion in some contexts (as manifested in the non-OIC sample).

This heterogeneity reconciles the paradox with institutional theory and highlights several structural mechanisms at play. First, as Islamic financial institutions mature, they frequently prioritize advanced, high-yield products such as sukuk issuances, structured funds and complex derivatives targeting corporate clients and high-net-worth individuals over basic retail products suitable for the mass market (Khémiri *et al.*, 2024). Second, Islamic finance operates through different risk-sharing and asset-backed models whose regulatory and policy landscapes differ from conventional banking, structurally shaping how institutional growth is transmitted to end users (Altamimi *et al.*, 2026). Furthermore, because technological innovation is ultimately adopted by corporate actors rather than institutional frameworks themselves, board expertise and internal governance may serve as the critical link between broader institutional conditions and the successful execution of digital transformation initiatives (Rabbani *et al.*, 2026). Third, market concentration exacerbates this divide, as financial development is typically driven by large, urban-based institutions with limited outreach to the rural and informal sectors where most unbanked individuals reside. Finally, voluntary exclusion compounds the effect, as conservative users may doubt whether modern financial engineered products genuinely comply with Sharī'ah principles, in line with the findings of Kaya (2023), Suseno and Fitriyani (2019) and Yorulmaz (2016).

Internet penetration remains a strong and consistent driver of inclusion across all models, reinforcing *H5*. The coefficients for connectivity generally exceed those for GIFT, indicating that digital infrastructure exerts independent direct effects on financial access beyond its facilitation of FinTech innovation. This pattern highlights why coordinated investments in fundamental connectivity constitute necessary complements to any FinTech promotion strategy. Among the control variables, unemployment negatively impacts digital transaction usage in the full and OIC samples, suggesting that joblessness constrains digital financial engagement, likely because of limited disposable income or reduced smartphone ownership. Interestingly, inflation shows positive coefficients across several models, potentially reflecting a shift toward rapid digital account utilization to manage money during periods of price instability.

4.7 Robustness check

To verify our findings, Tables 9 and 10 re-estimate the models using FGLS. As an alternative to PCSE, FGLS accounts for panel heteroskedasticity and autocorrelation through different

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Table 9. Robustness checks: Islamic FinTech determinants

	Model 1: IFDI → GIFT			Model 2: Interaction		
Variable	Full	OIC	Non-OIC	Full	OIC	Non-OIC
Islamic finance development (IFDI)	0.391*** (0.029)	0.579*** (0.032)	0.133 (0.082)	0.377*** (0.046)	0.515*** (0.050)	0.030 (0.102)
Internet penetration (INTERNET)	0.294*** (0.019)	0.267*** (0.028)	0.378*** (0.038)	−0.052 (0.042)	0.032 (0.052)	−0.378*** (0.071)
IFDI × internet (IFDI_INTERNET)	–	–	–	0.001 (0.002)	0.002 (0.002)	−0.004 (0.005)
GDP per capita growth (GDPPCG)	0.049 (0.058)	0.018 (0.084)	0.022 (0.109)	0.283*** (0.089)	0.133 (0.100)	0.356** (0.148)
Inflation (INF)	0.003 (0.011)	−0.001 (0.009)	−0.281*** (0.089)	0.004 (0.012)	−0.002 (0.011)	−0.005 (0.097)
Trade openness (TRADE_OPEN)	−0.011* (0.007)	−0.054*** (0.021)	0.000 (0.009)	0.035*** (0.009)	0.084*** (0.025)	0.027** (0.012)
Population growth (POP)	−0.095 (0.162)	−0.105 (0.242)	0.343 (0.280)	0.193 (0.287)	0.249 (0.493)	0.583 (0.380)
Unemployment (UNEMP)	−0.083(0.093)	−0.294** (0.138)	−0.120 (0.189)	0.888*** (0.118)	0.505*** (0.160)	0.586*** (0.199)
Governance (GOV)	1.511*** (0.267)	−0.472 (0.640)	0.679 (0.573)	4.603*** (0.457)	1.088(0.872)	6.185*** (0.721)
Constant	−0.881** (0.440)	−1.240 (0.910)	−1.173*** (0.436)	5.080*** (0.540)	6.263*** (1.166)	1.463*** (0.431)
Observations	256	172	84	256	172	84

Note(s): Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Source(s): Authors' own work

Table 10. Robustness checks: determinants of financial inclusion

Variable	Account ownership			Digital transactions		
	Full	OIC	Non-OIC	Full	OIC	Non-OIC
Islamic FinTech (GIFT)	0.397*** (0.075)	0.420*** (0.043)	0.576*** (0.217)	0.224*** (0.072)	0.349*** (0.069)	0.544*** (0.119)
Islamic finance development (IFDI)	−0.131*** (0.037)	−0.088*** (0.028)	−0.237* (0.130)	−0.093*** (0.025)	−0.019 (0.042)	−0.480*** (0.153)
Internet penetration (INTERNET)	0.440*** (0.058)	0.329*** (0.049)	0.609*** (0.119)	0.412*** (0.067)	0.324*** (0.062)	0.016 (0.228)
GDP per capita growth (GDPPCG)	0.591*** (0.148)	0.395*** (0.145)	1.394*** (0.436)	0.521*** (0.142)	0.220 (0.185)	−0.293* (0.171)
Inflation (INF)	0.217*** (0.043)	0.235*** (0.052)	0.768 (0.676)	0.195*** (0.041)	0.158*** (0.043)	1.188*** (0.261)
Trade openness (TRADE_OPEN)	−0.035*** (0.012)	0.036 (0.038)	−0.013 (0.011)	−0.037*** (0.012)	0.068* (0.036)	−0.075 (0.053)
Population growth (POP)	−0.042 (0.471)	0.344 (0.338)	1.774** (0.809)	0.219 (0.374)	−0.260 (0.621)	−0.471 (0.330)
Unemployment (UNEMP)	0.038 (0.200)	−0.986*** (0.224)	0.131 (0.190)	0.170 (0.231)	−1.258*** (0.248)	2.000*** (0.411)
Governance (GOV)	5.811*** (0.636)	1.292 (0.883)	−0.386 (1.216)	7.211*** (0.724)	−1.175 (1.134)	3.960*** (1.485)
Constant	10.036*** (1.284)	11.387*** (0.973)	8.423*** (2.904)	7.839*** (1.068)	7.668*** (1.611)	2.409** (0.937)
Observations	110	70	40	110	70	40

Note(s): Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Source(s): Authors' own work

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technical mechanisms, providing a valuable specification check. The FGLS estimates closely mirror the baseline results across all samples. Islamic finance development remains a robust driver of FinTech, Islamic FinTech consistently enhances both inclusion measures, and the IFDI-inclusion paradox persists within the full and non-OIC groups. With coefficient variations generally below 5%, these results confirm our main findings do not depend on specific estimator choices.

4.8 Endogeneity and sensitivity analysis

To address potential bidirectionality between Islamic finance development and FinTech, we use a 2SLS estimator, instrumenting the potentially endogenous regressor with its first lag. As reported in Table 11, Islamic finance development remains positive and highly significant in the FinTech model when instrumented (IFDI = 0.616, $p < 0.01$). This confirms that the relationship reflects a genuine directional effect from IFDI to FinTech rather than simultaneity. In the inclusion models, however, the lagged-GIFT instrument is relatively weaker because of the limited available data.

To account for potential distortions introduced by the post-COVID-19 digital shock, we conduct a sensitivity analysis that re-estimates the FinTech models while excluding 2021, the pandemic-peak year. As Table 12 demonstrates, the core results remain highly consistent. Islamic finance development continues to act as a strong, positive driver of FinTech (IFDI = 0.563, $p < 0.01$), and institutional governance retains its expected sign and significance.

The robustness check, endogeneity and sensitivity analyses validate the stability of our key findings. The positive effect of Islamic finance development on FinTech, the subsequent positive impact of FinTech on financial inclusion and the paradoxical negative association between institutional development and inclusion in non-OIC environments are all robust across alternative estimators and hold under instrumental variable specifications for endogeneity and the post-pandemic digital surge sensitivity check.

5. Conclusion

This study has examined the dynamic relationship between Islamic finance development, Islamic FinTech innovation and financial inclusion across 43 OIC and 21 non-OIC countries between 2021 and 2024. Drawing on institutional and innovation diffusion theories, the

Table 11. Endogeneity – two-stage least squares (2SLS) estimates

Variable	Model 1: GIFT (IFDI instrumented)	Account ownership (GIFT instrumented)	Digital transactions (GIFT instrumented)
Islamic finance development (IFDI)	0.616***	0.064	0.060
Islamic FinTech (GIFT)	–	0.022	−0.041
Internet penetration (INTERNET)	0.036	0.159	0.219
GDP per capita growth (GDPPCG)	−0.195	0.496	0.109
Inflation (INF)	0.004	0.169	0.141
Trade openness (TRADE_OPEN)	−0.017	−0.038*	−0.039
Population growth (POP)	−0.929**	−3.065	−1.437
Unemployment (UNEMP)	−0.138	−0.555	−1.027
Governance (GOV)	3.402***	7.362***	7.481***
Constant	15.285***	62.296***	55.063***

Note(s): ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Endogenous regressors instrumented by their first lag
Source(s): Authors' own work

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Table 12. Post-COVID sensitivity – FinTech models excluding 2021 (PCSE)

Variable	Model 1: IFDI → GIFT	Model 2: Interaction
Islamic finance development (IFDI)	0.563*** (0.045)	0.419*** (0.120)
Internet penetration (INTERNET)	0.213*** (0.020)	0.043 (0.051)
IFDI × internet (IFDI_INTERNET)	–	−0.000 (0.001)
GDP per capita growth (GDPPCG)	0.094 (0.112)	0.387* (0.213)
Inflation (INF)	0.034** (0.014)	0.017 (0.019)
Trade openness (TRADE_OPEN)	−0.042*** (0.011)	0.042* (0.025)
Population growth (POP)	0.569* (0.320)	1.565*** (0.547)
Unemployment (UNEMP)	−0.055 (0.051)	0.374 (0.232)
Governance (GOV)	2.285*** (0.350)	3.196*** (0.633)
Constant	0.589 (0.550)	6.951** (2.680)

Note(s): Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Source(s): Authors' own work

study used PCSEs as the primary estimator, with FGLSs and 2SLSs for robustness and endogeneity, to address cross-sectional dependence, slope heterogeneity and reverse causality inherent in cross-country data. All models incorporated a principal component governance index and were estimated separately for the full, OIC and non-OIC subsamples, with a post-2021 sensitivity check.

The empirical findings show mixed support for the study's hypotheses. *H1* receives strong validation, with Islamic finance development significantly fostering Islamic FinTech growth (0.508, $p < 0.01$). *H3* is robustly supported, indicating that Islamic FinTech positively impacts both account ownership (0.268, $p < 0.01$) and digital transaction usage (0.375, $p < 0.01$). *H5* is also confirmed, showing internet penetration's strong direct effects on financial inclusion. However, *H2* is rejected as the interaction effect is small and insignificant after controlling for governance, suggesting threshold dynamics in which the marginal effect of digital infrastructure declines at higher levels of penetration. More importantly, *H4* is rejected, with Islamic finance development negatively associated with financial inclusion ($\beta = -0.088$ and -0.172, $p < 0.05$). This pattern is driven by non-OIC countries, while it is weakly positive in OIC contexts, challenging the assumption that institutional maturity automatically translates into inclusive outcomes.

As such, the results carry important practical policy implications. Current strategies have deepened existing segments rather than expanding to the unbanked, reflecting product complexity, credibility concerns and urban-focused market concentration. Regulatory frameworks, therefore, need to encourage Islamic financial institutions to offer simple, accessible products alongside advanced services. Perhaps targeted regulatory incentives, such as inclusion mandates or support for agents and digital banking, are needed to inspire these institutions to expand beyond urban and high-income segments and increase outreach to underserved and rural communities. To this effect, supporting grassroots Islamic FinTech initiatives, such as mobile zakat platforms, agent-based services and blockchain-enabled microfinance, may provide scalable channels for reaching underserved populations. Furthermore, national Islamic FinTech strategies should prioritize investments in digital infrastructure while complementing connectivity with regulatory clarity, financial literacy initiatives and user-oriented product design.

This research contributes to the literature by providing the first cross-country empirical analysis linking Islamic finance development, FinTech innovation and financial inclusion using standardized metrics across diverse institutional contexts. The findings challenge

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linear assumptions about financial development by revealing disconnects between institutional maturity and inclusive access, a pattern with broader relevance beyond Islamic finance. The results are robust to alternative estimators (FGLS and 2SLS) and to the exclusion of the pandemic-shock year, and the OIC and non-OIC split shows the inclusion paradox is a non-OIC phenomenon rather than a universal one.

Despite these contributions, the study has some limitations inherent to the emerging nature of Islamic FinTech research. The analysis is limited to the period 2021–2024. This reflects the recent availability of standardized cross-country indicators for Islamic FinTech and related measures. On the other hand, the use of aggregate country-level data does not fully capture within-country disparities that may shape adoption patterns. The lack of indicators specific to Islamic financial inclusion also necessitated the use of general financial inclusion indicators. This may obscure dynamics unique to Sharī'ah-compliant financial services. As more comprehensive and disaggregated data sets become available, future research could extend the analysis using longer time periods and micro-level evidence to better assess the distributional and long-term impacts of Islamic FinTech on poverty reduction, financial inclusion and small and medium-sized enterprises. Complementary mixed-method approaches would further help illuminate contextual adoption mechanisms, while focused investigations into emerging applications, such as AI-based Sharī'ah compliance, blockchain-enabled zakat distribution and digital identity solutions, represent promising directions for advancing the field.

The convergence of Islamic finance and digital innovation offers a pathway to extend ethical and inclusive financial services to populations excluded from formal systems. Realizing this potential requires measured policy and regulatory design to ensure that Islamic FinTech expansion translates into genuine inclusion rather than relying on institutional development alone.

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Ethics statement
All data used in this study are aggregate country-level statistics with no human participants.

Data availability
This study uses publicly available secondary data from the World Bank's 2021 Global Findex Database, Global Islamic Fintech (GIFT) index reports (DinarStandard and Elipses), Islamic Finance Development Indicator (Refinitiv Eikon/LSEG) and World Bank World Development Indicators. The compiled panel data set will be made available upon request to the corresponding author.

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Further reading

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Appendix. List of countries in the sample

Table A1. Countries included in the sample

OIC member countries	Non-OIC member countries
1. Afghanistan	44. Australia
2. Albania	45. Bosnia and Herzegovina
3. Algeria	46. Canada
4. Azerbaijan	47. China
5. Bahrain	48. France
6. Bangladesh	49. Germany
7. Brunei	50. Hong Kong
8. Burkina Faso	51. India
9. Cameroon	52. Japan
10. Egypt	53. Kenya
11. Gambia	54. Luxembourg
12. Indonesia	55. The Philippines
13. Iran	56. Russia
14. Iraq	57. Singapore
15. Ivory Coast	58. South Africa
16. Jordan	59. Spain
17. Kazakhstan	60. Sri Lanka
18. Kuwait	61. Switzerland
19. Kyrgyzstan	62. Thailand
20. Lebanon	63. United Kingdom
21. Libya	64. USA
22. Malaysia	
23. Maldives	
24. Mali	
25. Mauritania	
26. Morocco	
27. Niger	
28. Nigeria	
29. Oman	
30. Pakistan	
31. Palestine	
32. Qatar	
33. Saudi Arabia	
34. Senegal	
35. Sudan	
36. Suriname	
37. Syria	
38. Tajikistan	
39. Tunisia	
40. Turkey	
41. United Arab Emirates	
42. Uzbekistan	
43. Yemen	

Note(s): The sample comprises 43 OIC member countries and 21 non-OIC countries with established Islamic finance presence or Islamic FinTech activity, as identified by the Global Islamic Fintech (GIFT) index reports (2021–2024)

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