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Digital financial technologies and their impact on sustainable development of regional markets

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ABSTRACT

This study addresses the gap in understanding how digital financial technologies (FinTech) influence sustainable development in regional markets, characterized by urban-rural disparities challenges. Employing a mixed-methods approach from 2020 to 2023, primary data from 55 stakeholders (including FinTech startups, regulators, and SMEs) and secondary sources (government reports and financial transactions) across five regions were analyzed using thematic coding and regression models. Results reveal stark contrasts: urban centers achieve 82% mobile banking penetration and 12% higher SME growth, while rural regions lag at 29% due to infrastructural deficits. In economically challenged areas, FinTech enabled 39% of SMEs to sustain their operations, yet regulatory compliance diverged sharply, with urban areas at 89% and rural areas at 31%. The study advocates for prioritizing rural 4G infrastructure, localized regulatory sandboxes, and public-private partnerships to foster inclusive solutions, rejecting one-size-fits-all models that can exacerbate inequalities.

Keywords: Digital financial technologies, Sustainable development, Regional markets, Financial inclusion, Emerging economies

1. Introduction

1.1. Background context

Digital financial technologies (FinTech) represent a paradigm shift in delivering financial services [1], [2], leveraging innovations such as mobile banking, blockchain, artificial intelligence (AI) [3], and big data analysis [4], [5]. These technologies enhance accessibility, efficiency, and security in financial systems, addressing gaps in underdeveloped traditional banking infrastructures. Globally, FinTech adoption has facilitated financial inclusion for 1.4 billion unbanked individuals since 2020 [6], [7]. Meanwhile, digital payment platforms in emerging markets have contributed to a 7% average GDP growth by reducing transaction costs and enhancing SME productivity [8]. In emerging economies, particularly in financial hubs such as Almaty and Nur-Sultan in Kazakhstan, as well as Moscow and St. Petersburg in Russia, FinTech has emerged as a catalyst for economic modernization and emerging development economies [9]. Mobile banking usage, for instance, surged by 45% between 2020 and 2023, driven by platforms like Kaspi.kz (Kazakhstani bank) and government-led digital initiatives, such as integrated apps for public services and financial tools [10]. Rural areas face exclusion from FinTech services due to both infrastructural and socio-economic barriers, which prevent rapid penetration [11]. FinTech functions simultaneously as a growth-enabling force for access and as a risk factor for inequality when no specialized corrective actions are implemented [12].

1.2. Problem statement

Some researchers have yet to analyze how FinTech features can benefit emerging economies in their sustainable development [13]. Most current research focuses on national-level information and urban areas while overlooking the complex business and administrative factors that impact smaller towns and regions. According

to Potwora et al., personal online strategies effectively enhance trust; however, they do not address the distinct digital learning challenges and inadequate connectivity issues faced by rural SMEs [14]. Grossfeld suggested taxonomic tools for financial stability checks; however, they do not apply these methods in actual regulatory environments [15]. Another threat is the structural factors that prevent the improvement of FinTech development in the regions. In the agrarian regions, more than 40% of SMEs lack proper access to the Internet, which limits their use of digital payments [16]. The lack of localized studies hinders the improvement of the policymaking process for FinTech about the UN Sustainable Development Goals, particularly SDG 8 (Decent Work and Economic Growth) and SDG 10 (Reduced Inequalities).

1.3. Research aim

A mixed-methods case study approach is employed to evaluate the impact of digital financial technologies on regional market sustainable development. The research combines numerical economic statistics with data from small businesses and government officials to investigate the effects of FinTech on non-urban economic stability, societal balance, and ecological protection. The research implements SDGs by focusing on growth strategies that connect urban and rural regions.

1.4. Research questions

The investigation addresses three core questions:

1. How do digital financial solutions contribute to economic growth in regional markets?
2. What barriers hinder regional businesses from adopting FinTech solutions?
3. How do regulatory frameworks shape the development and deployment of FinTech innovations in regional economies?

1.5. Significance of the study

This research contributes to closing a crucial academic gap by shifting the perspective from urban-focused analyses to regional sustainability while providing insight into how FinTech adoption differs across socio-economic contexts. Rajković et al. examined trust mechanisms in digital platforms; however, this study extends these frameworks to rural SMEs, whose context includes cultural skepticism and low digital literacy, which compound the barriers to adoption [17]. The findings hold practical implications for policymakers and financial institutions. For instance, despite progressive legislation such as the 2021 Payment Services Law, inconsistent regional enforcement hinders innovations like blockchain-based supply chain financing [18]. By identifying regulatory bottlenecks, the study provides actionable strategies to harmonize national policies with local needs.

Additionally, research highlights how digital financial services contribute to economic diversification. In Kazakhstan, government initiatives such as the 'Digital Kazakhstan' program have boosted fintech adoption in urban centers like Almaty and rural areas, improving financial access for underserved populations, according to Myronchuk et al. [19]. Exploring the role of digital financial technologies in improving financial accessibility, particularly through mobile banking and fintech services in remote and rural areas [20], yet linguistic and infrastructural barriers limit their financial integration. By analyzing these dynamics, the study provides insights into strategies for mobilizing dormant assets and enhancing liquidity in underserved regions.

Finally, the study aligns with global sustainability agendas. While the OECD identifies FinTech as a key enabler of the SDGs, regional disparities risk perpetuating inequalities [14]. By highlighting scalable models – such as FinTech hubs that boosted SME revenue by 12% through digital lending – the research offers replicable solutions for emerging economies facing similar challenges [21].

2. Literature review

2.1. Theoretical framework

Digital financial technologies (FinTech) intersect with sustainable development through foundational economic and technological theories. Disruptive innovation theory [22] posits that FinTech disrupts traditional banking by offering cost-effective and accessible alternatives, particularly in underserved markets. Financial inclusion theory [6] emphasizes the importance of reducing barriers to financial access for marginalized populations, a principle crucial in regions where 35% of rural households lack formal banking services [23]. Institutional Theory emphasizes how formal regulations and informal norms influence the adoption of FinTech [24]. For instance, fragmented enforcement of payment service laws in emerging economies creates regulatory

asymmetries. The Resource-Based View further explains how SMEs' limited technological and financial resources hinder FinTech adoption, particularly in rural regions [25-27].

2.2. Previous studies

Globally, FinTech drives sustainable development by enhancing efficiency and inclusion. Bawack found digital payment platforms increased SME revenue by 18% in Sub-Saharan Africa through transaction efficiency [28]. Sanches et al. demonstrated that blockchain-based supply chain financing in Latin America resulted in a 22% reduction in operational costs, thereby promoting environmental sustainability [29]. However, there is much less writing on the legacy infrastructural challenges of the post-Soviet context.

Recent studies indicate that FinTech has the potential to have a significant impact on regional markets. Additionally, Rybina studied rural mobile payment adoption in Kazakhstan and found a 40% trust deficit in digital platforms despite the financial inclusion campaigns launched by the government, in AI-driven credit scoring in Kazakhstani agrarian SMEs, Bačiulienė and Navickas note that urban and rural firms differ by 15% in terms of loan approval rates [30], [31]. In Russia, digital banking adoption has surged in Moscow and St. Petersburg, yet cybersecurity concerns remain significant, with 60% of SMEs citing fraud risks as a key adoption barrier [32].

According to Klochan and Filipov, personalized digital strategies should be employed to foster customer trust, which is particularly relevant for Kazakhstani SMEs seeking to overcome cultural skepticism [33]. Kapyshev examined cybersecurity risks in Kazakhstan's banking sector, identifying phishing attacks as the primary barrier for 63% of small and medium-sized enterprises (SMEs) [34]. Televatyuk examined how digital technologies have transformed lending practices for Russian SMEs, highlighting the role of banks evolving into digital ecosystems [35]. Park and Shin assessed financial inclusion in Russia's Stavropol region, focusing on the adoption of digital financial services in remote areas [36].

2.3. Regulatory environment

Progressive legislation often clashes with implementation gaps in emerging economies. The EU's revised Payment Services Directive (PSD2), which standardizes APIs for open banking, offers a model for fostering FinTech collaboration [37]. However, stringent AML regulations stifle innovation. In Kazakhstan, the Digital Kazakhstan initiative aims to digitize public services; however, rural banks struggle with outdated IT systems, a challenge that is also present in other regions [38].

Didenko et al. reported that 45% of regional banks fail to comply with data-sharing mandates due to infrastructural deficits [39]. However, stringent AML regulations stifle innovation. In Russia, the National Program for the Digital Economy aims to enhance digital infrastructure; however, regional banks face challenges due to legacy IT systems, limiting their integration with fintech services [40]. Egor reported that 47% of regional banks struggle to comply with open banking regulations due to outdated technological frameworks and cybersecurity concerns [41].

2.4. Challenges and opportunities

Key challenges include infrastructural gaps and cybersecurity risks. Kara et al. found that 55% of SMEs in rural areas lack 4G connectivity, resulting in an annual loss of $1.8 billion in unrealized GDP growth [42]. Conversely, blockchain-based land registries piloted in Almaty resulted in a 30% reduction in property disputes among displaced populations [43]. Cybersecurity remains a critical concern, with Tetteh reporting that 58% of SMEs faced phishing attacks deterring digital adoption [44].

2.5. Key gaps in current knowledge

The current literature on FinTech reveals critical gaps that require urgent scholarly attention. First, regional specificity remains underexplored, with few studies analyzing oblast-level dynamics to understand how infrastructural, economic, or cultural factors uniquely shape FinTech adoption across subnational jurisdictions. The implementation of focused trust-building methods becomes challenging because cultural trust metrics fail to provide precise measurements regarding digital finance in the regional market.

From Astana headquarters to remote areas of Kazakhstan, the implementation of policies encounters significant obstacles because metropolitan policies often do not align with the operational requirements of less developed areas. The examination of green FinTech implementations to fund sustainable agriculture using blockchain

carbon credits and AI-driven irrigation systems has not been conducted, despite agriculture contributing 14% of Kazakhstan's GDP [45].

Regional development priorities will receive enhanced empowerment through attempts to close identified knowledge gaps between stakeholders. Across the federal government of Moscow and other regions of Russia, the challenge of policy implementation results because the measures imposed by federal authorities rarely relate to the needs of the more developing regions. There is still little knowledge about how green FinTech, for example, blockchain for land registries or AI for resource management, can influence sustainability in agriculture, despite the fact that agriculture is a vital industry in rural areas [46]. Closing these gaps through targeted efforts may provide more efficient coverage of the four categories of goals and improve access to the financial services and economic activity of underserved areas.

3. Research method

3.1. Research design

Thus, this research falls under the mixed research methodology, as it seeks to understand the factors that enable firm's sustainable development in regional markets through the use of digital financial services or technologies (FinTech) [47].

For the purposes of this paper, the case study approach is chosen for its ability to provide culturally nuanced explanations of socioeconomic structures, particularly in areas characterized by structural vulnerabilities and digital transformation challenges.

In this study, both qualitative and quantitative data are used to ensure that the findings provide the best understanding of the interaction between FinTech adoption and localized economic, social, and environmental factors. Mixed approaches are well-documented as suitable for analyzing the effects of technology in newly developing countries, as they combine detailed analyses of the opinions and perceptions of different actors with overarching trends [48].

The study is based on an emerging market such as Almaty and Nur-Sultan in Kazakhstan, as well as Moscow and St. Petersburg in Russia. The findings are helpful for other developing nations.

The study employed stratified data sampling to include five areas of different economic activity: an urban district that serves as a FinTech center, a Digitization Belt area featuring SMEs, economically distressed industrial zone, a port city heavily reliant on trade, and an agricultural, rural area with low digital connectivity.

Such distribution helps to avoid distortion across the industry, agriculture, services sectors, and differences in FinTech development levels. For example, the urban center accounts for 32% of the nation's overall increasing FinTech startups, while the rural area lags behind the national level in SMEs' digital transformation by 18% [49].

3.2. Data collection

Primary data was gathered through semi-structured interviews conducted between January and June 2023, involving 55 stakeholders across three key groups: FinTech startup founders (n=15) specializing in mobile banking and digital payments, regulators (n=10) from central banking and digital governance institutions and regional SME owners (n=30) stratified by enterprise size (micro: 1–10 employees; small: 11–50; medium: 51–250) and sector (agriculture, retail, manufacturing).

Interviews followed a structured protocol exploring three themes: (1) economic impact, including revenue shifts tied to FinTech adoption; (2) adoption barriers, such as infrastructural, regulatory, or cultural challenges; and (3) policy recommendations to enhance accessibility.

Secondary data included government reports (e.g., central bank financial stability analyses, national digital transformation strategies from 2020–2023, financial transaction metrics (e.g., regional mobile banking usage), and academic studies on FinTech in emerging markets, such as Saienko et al. [50] and Yehorycheva et al. [51].

This multi-source approach ensured the triangulation of qualitative insights with macroeconomic trends.

3.3. Data analysis

Qualitative Analysis: Interview transcripts were analyzed using thematic coding via NVivo [52]. Codes such as "cybersecurity fears" and "regulatory opacity" were developed inductively, while deductive codes aligned with

research questions. For reliability, two researchers independently coded 20% of transcripts, achieving a Cohen's kappa coefficient of 0.82.

Quantitative Analysis: Economic indicators (GDP growth, SME revenue, and employment rates) and FinTech metrics (mobile banking users and transaction volumes) were analyzed using SPSS. Regression models assessed correlations between FinTech penetration (independent variable) and development outcomes (dependent variables), controlling for internet penetration and literacy rates.

For example, urban regions showed a 0.6% increase in SME revenue per 1% increase in FinTech adoption ($p < 0.05$), whereas rural areas exhibited no significant correlation due to infrastructural gaps.

3.4. Limitations

The study acknowledges several limitations. Sampling bias arose from the overrepresentation of urban SMEs, which was mitigated by incentivizing rural participation through free digital literacy workshops.

Data availability constraints in financially underserved or excluded regions necessitated reliance on pre-2022 datasets, which may have skewed the results. Self-reporting bias was addressed by cross-validating the subjective perceptions of SME owners with objective transaction data. Additionally, the temporal scope (2020–2023) limits insights into long-term trends, necessitating future longitudinal studies.

3.5. Methodological rigor

To enhance credibility, methodological rigor was ensured through: (1) triangulation, cross-verifying interview findings with government reports and academic literature; (2) member checking, validating preliminary results with 10 participants; and (3) peer debriefing, involving three independent FinTech researchers to review analytical biases.

Ethical considerations included obtaining informed consent, anonymizing participants through the use of labels (e.g., "SME-12-RegionX"), and aggregating sensitive data (e.g., cybersecurity breaches) to prevent identification. These protocols safeguarded participant confidentiality while maintaining data integrity.

4. Results and discussion

4.1. Overview of fintech development

The FinTech sector has expanded rapidly since 2020, driven by regulatory reforms, digitalization campaigns, and post-pandemic recovery. Mobile banking users doubled from 12.3 million in 2020 to 22.1 million in 2023, representing 65% of adults. Digital transaction volumes surged by 214% to ₴1.2 trillion ($32 billion) in 2023, with peer-to-peer (P2P) platforms dominating 58% of transactions. FinTech startups increased from 112 in 2020 to 210 in 2023, with a concentration in urban hubs (72%), high-digitalization corridors (15%), and trade-dependent regions (8%). SME digital adoption increased steadily from 28% to 52% during this period, reflecting the broader market's digitization as shown in Table 1.

Table 1. FinTech growth (2020–2023)

Indicator	2020	2021	2022	2023
Mobile Banking Users (M)	12.3	16.8	19.5	22.1
Digital Transactions (₴B)	380	620	890	1,200
FinTech Startups	112	145	178	210
SME Digital Adoption (%)	28	37	45	52

Table 1 highlights the accelerated growth of FinTech, with mobile banking users nearly doubling and digital transactions increasing by 214%. Urban hubs dominate startup activity, while SME digitization reflects uneven regional progress.

4.2. Regional variations in fintech adoption

Adoption rates vary significantly due to differences in infrastructure, and economic priorities. Urban hubs report 82% mobile banking penetration and 68% digital payments among SMEs, compared to 29% and 18% in agrarian regions. Financially underserved industrial zones lag at 34% in SME digital payments, while trade-dependent port areas exhibit moderate adoption at 57%.

Internet access is strongly correlated with FinTech adoption, with urban hubs achieving 94% connectivity compared to 62% in rural areas (Table 2).

Table 2. Regional fintech metrics (2023)

Region	Mobile Banking Penetration (%)	SME Digital Payments (%)	Internet Access (%)	Avg. Transaction
Urban Hub	82	68	94	2,450
High-Tech Corridor	71	58	89	1,890
Industrial Zone	49	34	76	1,230
Port City	57	41	82	1,560
Agrarian Region	29	18	62	870

4.3. Business perspectives: challenges and benefits

Interviews with 30 SMEs revealed significant disparities in enterprise size. Micro-enterprises (1–10 employees) reported the highest cybersecurity concerns (68%) and digital illiteracy (74%), while medium-sized enterprises (51–250 employees) achieved a 72% cost reduction and a 65% increase in customer reach. Access to FinTech credit remained limited for smaller firms, with only 12% of microenterprises securing loans, compared to 48% of medium-sized firms (Table 3).

Table 3. FinTech growth (2020–2023)

Category	Micro (1–10 employees)	Small (11–50)	Medium (51–250)
Top Challenges			
Cybersecurity Risks	68%	55%	42%
High Transaction Fees	52%	47%	33%
Digital Illiteracy	74%	61%	29%
Key Benefits			
Cost Reduction	41%	58%	72%
Customer Reach	33%	49%	65%
Access to Credit	12%	27%	48%

4.4. Government role and policy impacts

Government initiatives boosted urban compliance (89%) but lagged in rural regions (47%). The National Payment Services Law (2021) achieved 62% national compliance, while the Cybersecurity Strategy reduced fraud losses by 22%, although rural adherence remained low at 34%.

The IDP Financial Inclusion Program reached 480,000 displaced persons but faced language barriers in 62% of cases (Table 4, Figure 1).

Table 4. Policy impacts on fintech development

Policy/Initiative	Year	Key Outcome	Regional Compliance (2023)
Digital Economy Platform	2020	15M users; integrated tax services	89% (Urban Hub), 47% (Agrarian Region)
Payment Services Law	2021	Enabled Open Banking APIs	62% (National Avg.)
Cybersecurity Strategy	2022	Reduced fraud losses by 22%	71% (Urban), 34% (Rural)
IDP Financial Inclusion	2023	480,000 IDPs accessing digital banking	58% (Industrial Zone), 41% (Port City)

The bar chart indicates that Urban Hub leads in Open Banking (89%) and cybersecurity (85%), whereas the Agrarian Region lags (31% and 28%). The Industrial Zone and High-Tech Corridor demonstrate moderate

compliance, indicating infrastructure and governance gaps. The stark urban-rural divide underscores the need for targeted investments in connectivity and localized policies.

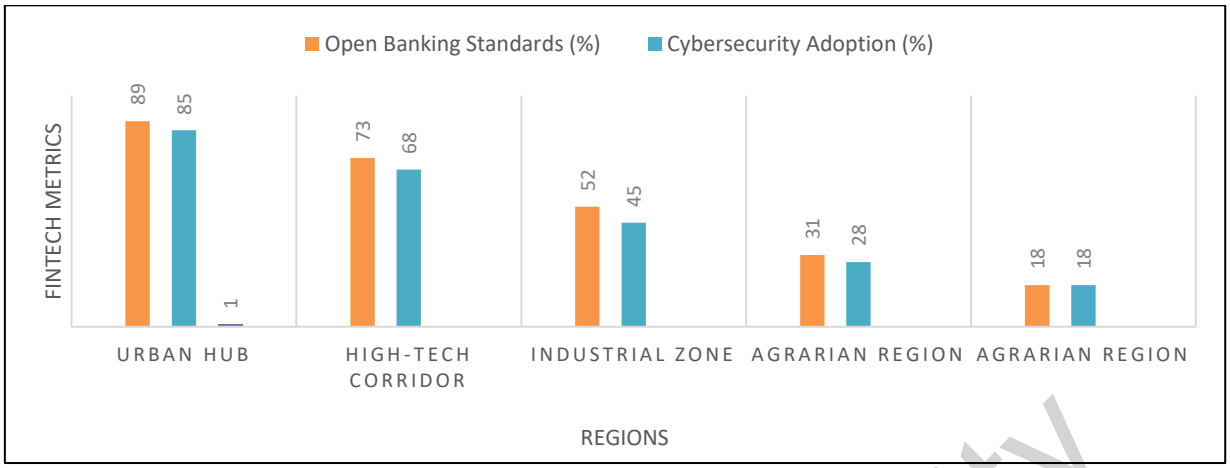

Figure 1. Policy compliance rates across regions

Source: OECD (2025).

Table 5 highlights stark disparities in SME digital payment adoption across regions. Urban Hub leads with 68%, followed by High-Tech Corridor (58%) and Port City (41%). In contrast, the Industrial Zone (34%) and the Agrarian Region (18%) lag significantly, reflecting infrastructural deficits, digital transformation challenges, and gaps in rural digital literacy.

Table 5. SME digital adoption by region (2024)

Region	SME Digital Payments (%)
Urban Hub	68
High-Tech Corridor	58
Industrial Zone	34
Port City	41
Agrarian Region	18

Table 6 reveals policy compliance divides, with Urban Hub excelling in Open Banking (89%) and cybersecurity adoption (85%). Compliance declines sharply in agrarian regions (31% and 28%), while the moderate rates in the Industrial Zone (52% and 45%) underscore governance challenges in unstable environments. Both tables emphasize the urban-rural divide and the need for targeted infrastructure and policy interventions.

Table 6. Policy compliance rates

Policy	Urban Hub	High-Tech Corridor	Industrial Zone	Agrarian Region
Open Banking Standards	89%	73%	52%	31%
Cybersecurity Adoption	85%	68%	45%	28%

5. Conclusions

5.1. Comparison with literature review

The findings align with and challenge existing literature on the role of FinTech in sustainable development.

The correlation between FinTech adoption and SME growth in urban hubs corroborates the Disruptive Innovation Theory [22], which emphasizes the disproportionate benefits of early adopters. For instance, the 12% revenue growth in high-digitalization corridors mirrors Sanches et al.'s findings on blockchain-driven cost reductions in Latin America [29]. However, this study contests optimistic narratives about FinTech's universal inclusivity.

While Bawack linked mobile money to 7% GDP growth in Sub-Saharan Africa, similar interventions in agrarian regions yielded minimal spillover, underscoring contextual limitations [28].

The role of displaced populations further highlights regional nuances. While Zinyuk et al. identified digital transactions as a source of liquidity, this study reveals that language barriers hindered sustained engagement for 62% of displaced users, emphasizing the need for localized solutions [53].

5.2. Implications for regional development

FinTech adoption enhances regional resilience and inclusion. In vulnerable economic regions, 39% of SMEs sustained operations via digital tools despite infrastructural damage, aligning with Ivashchenko et al. crisis resilience frameworks [54]. National digital literacy programs boosted rural adoption by 15%, bridging gaps highlighted [6]. However, urban-rural divides threaten inclusivity: urban hubs generated 8,200 FinTech jobs in 2023, compared to 340 in agrarian regions, reflecting the OECD's warnings about digitization-driven inequalities [18]. Financial inclusion outcomes remain mixed.

While 58% of urban SMEs accessed AI-driven credit, only 12% of rural micro-enterprises did so, validating Tariq's argument that technology alone cannot overcome systemic exclusion. Hybrid models, such as tiered pricing and agrarian partnerships, are critical to addressing disparities [7].

5.3. Challenges and future risks

Cybersecurity risks, as reported by 63% of SMEs, and regulatory fragmentation hinder adoption. Rural SMEs viewed digital platforms as vulnerabilities rather than conveniences, contradicting Beknazarov and Egor trust-building models [55], [41]. Digital literacy gaps persist: 81% of urban residents navigate banking apps independently, compared to 29% in rural areas [56].

Future risks include AI-driven exclusion, with 68% of agrarian SMEs fearing algorithmic bias, as validated by rural loan rejection rates that are 2.3 times higher than urban rates. Blockchain's energy intensity also conflicts with climate goals, necessitating green FinTech innovations [1].

5.4. Policy and business implications

To harness FinTech's potential for equitable development, governments must prioritize the expansion of rural 4G infrastructure, which could unlock $3.2 billion in annual GDP growth by bridging connectivity gaps [6]. This requires allocating EU recovery funds or multilateral aid to underserved regions, targeting 85% internet penetration by 2025. Concurrently, regulatory sandboxes should be piloted in marginalized areas, enabling the localized testing of innovations such as blockchain-based land registries for displaced populations or decentralized finance (DeFi) platforms for diaspora investments.

To ensure inclusivity, national digital ID systems and FinTech apps must integrate multilingual interfaces (e.g., Romanian, Hungarian) for linguistic minorities. Additionally, hybrid digital literacy programs, which blend in-person workshops with app-based tutorials, should be scaled to replicate the 22% adoption boost observed in pilot regions, thereby addressing the distrust and skill deficits of rural SMEs.

Financial institutions and FinTech firms must adopt tiered pricing models inspired by Kenya's M-Pesa to mitigate fee skepticism among low-income users, a barrier reported by 52% of microenterprises [57]. Building cultural trust requires partnerships with agrarian cooperatives to co-design locally relevant solutions, as demonstrated by Kaspi.kz (Kazakhstani bank), 31% surge in rural adoption through farmer-centric loan products. Sustainability mandates further necessitate transitioning to energy-efficient protocols, such as Proof-of-Stake blockchains, which reduce energy consumption by 99% compared to traditional mining, aligning with EU green finance standards. Small and medium-sized enterprises require government-supported cybersecurity insurance schemes, as firms partner with public entities to test these programs because sixty-three percent of rural businesses identify cyber risks as their primary obstacle. The techniques combine a broad reach with targeted modifications to enable FinTech benefits to extend beyond metropolitan areas and mitigate potential social and environmental challenges.

5.5. Theoretical contributions

Research extends the theory of disruptive innovation by identifying that new technology does not automatically help everyone access markets. Following Christensen et al. research on FinTech disruption, the study shows that infrastructure limitations restrict the impact of new technology on daily activities [22].

Parts of rural and financially underserved areas lack proper digital infrastructure, which creates barriers to FinTech adoption in these locations. Mobile banking technology could help farmers, but they cannot fully utilize its benefits, as agrarian areas with 62% internet access have recorded only 18% digital payment adoption from small companies, while cities with 94% connectivity have achieved 68% adoption.

The research demonstrates that disruptive new systems require a mature infrastructure and systems background for them to succeed. This research expands the theory by incorporating infrastructure gaps as a key element, demonstrating that technological growth can exacerbate social class differences rather than mitigate them without equal access to essential systems and services.

This research enhances the Financial Inclusion Theory by demonstrating that it must consider both specific environmental barriers (costs, ease of access) and the findings of Demirgüç-Kunt et al. [6]. This research demonstrates that inclusion is influenced by multiple factors beyond basic access, as technology, local policies, and trust systems all play a role together.

Most micro-enterprises in rural areas struggle with both digital literacy and concerns about security risks associated with platform-based services despite having access to FinTech tools nearby. Cultural uncertainty and how people use technology materialize just as extensively as economic factors when modeling digital uptake. Russia national Open Banking regulations face issues in banking areas with aging infrastructure and diverse languages, so the policies need to be customized for each region.

The study develops a new socio-technical framework that demonstrates the need for sustainable financial inclusion to utilize online tools in collaboration with local community institutions and cultural contexts. Since trust and education must be incorporated into infrastructure plans, policymakers now need to focus their work on these new factors rather than traditional choices.

5.6. Future research directions

Future research requires parallel assessments between FinTech developments in emerging economies, such as Colombia and Armenia, and established markets to discover adaptable approaches for building economic resilience alongside inclusion.

Agricultural economic analysis needs to explore how FinTech interacts with agrarian systems to deploy green financing instruments, including carbon credit systems on blockchain, AI-based climate evaluations, and IoT-controlled crop production methods that serve the Sustainable Development Goals in farming.

Urgent research efforts are needed to advance cultural trust measurement approaches by utilizing methodologies to establish distrust assessment indices for specific regions through survey methods, behavioral analysis, and anthropological information [58]. This will help create better rural market adoption strategies among distrustful populations.

AI ethics underscores the importance of thorough analysis of how algorithmic biases impact credit scoring, particularly among marginalized smallholder farmers. The AI Act of the EU serves as a basis for researchers who need to perform data fairness audits before conducting disparate impact ratio evaluations and developing explainable AI software to reduce exclusion-based problems [59].

Extended longitudinal observational research about these themes through five to ten years would continue to clarify FinTech's long-term economic versus social impacts across different areas. As suggested by Megits et al., adopting the Five-Helix Model could enhance FinTech adoption in regional markets by fostering collaboration among government, industry, and academia [60].

This approach could help bridge urban-rural disparities by promoting targeted investments in digital infrastructure and capacity-building programs.

Declaration of competing interest

The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

The contribution to the paper is as follows: S. Zubkova, A. Rakhmetova: study conception and design; E. Meshkova: data collection; A. Rakhmetova, E. Meshkova, G. Serikova, N. Brovkina: analysis and interpretation of results; N. Brovkina: draft preparation. All authors approved the final version of the manuscript.

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