FUNDAÇÃO GETULIO VARGAS
ESCOLA BRASILEIRA DE ADMINISTRAÇÃO PÚBLICA E DE EMPRESAS
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THE IMPACTS OF FINTECH INNOVATION ON FINANCIAL INCLUSION AND FINANCIAL STABILITY: A CROSS-COUNTRY STUDY

DÁRIO ANTÔNIO LEITE MARTINS DE SANT'ANNA

Rio de Janeiro - 2024

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ABSTRACT

Globally, notwithstanding all the financial innovations of the digital era, there are still 1.4 billion people who are excluded from the formal financial system, a reality that precludes them from achieving financial health and wellness. Over the last few years, technological-enabled financial innovation—also known as financial technology or fintech—has gained increasing global attention as a powerful tool to make financial systems more efficient and competitive and to promote socio-economic development. However, the hype and confusion around fintech may be masking the risks this intriguing innovation poses to the stability of the financial system and, ultimately, to low-income people. Such background reflects the scarcity of empirical analyses on the outcomes of fintech innovation. We explore this research gap by investigating how the combination of financial and technological innovations can help integrate the financially excluded segments of society into the formal financial system and the impact of such innovation on financial stability. To that end, we use a Generalized Method of Moments (GMM) balanced panel with 82 countries from 2013 to 2021 to advance the understanding of the interrelationship between fintech innovation, financial inclusion, and financial stability. The results support our theorizing that the relationship between fintech innovation and financial stability is mediated by financial inclusion; in contrast, individuals' financial capabilities and regulatory and supervisory frameworks perform moderation roles in this interrelationship. Our study contributes to furthering the understanding of the relationship between financial and technological innovations and their economic implications.

Keywords: financial inclusion, fintech, financial innovation, inclusive innovation, digital finance, mobile banking, and financial stability.

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1 – INTRODUCTION

Despite the development of the financial sector, most of the world's underprivileged population remains unbanked and lacks access to affordable financial services–a sad reality faced by small entrepreneurs, especially in emerging economies. Some estimates suggest that, globally, 38% of all adults lack access to basic financial services, and 57% do not have access to diversified investment and savings options, low-cost payment systems, insurance, or credit, although they have basic accounts (Demirgüç-Kunt et al., 2022). This means that 1.4 billion people globally lack access to the financial services they need to achieve modest financial well-being (Patwardhan et al., 2018). A lack of access to financial services is not just a symptom but also one of the contributing factors of wealth inequality (Florant et al., 2020). Without the ability to save, invest, and insure against risk, many financially underserved families struggle to transform income into wealth.

Due to its potential effects on economic growth, poverty reduction, and financial stability, financial inclusion is increasingly becoming a top priority for policymakers (García, 2016), regulatory officials (Demirgüç-Kunt et al., 2018), and researchers (Beck, 2020) around the world. Multilateral development agencies have also started implementing initiatives to promote financial inclusion in marginalized communities, such as the Global Partnership for Financial Inclusion, the Maya Declaration, the United Nations Sustainable Development Goals, and the World Bank 2020 goal of universal financial access. However, empirical evidence on the macroeconomic impact of financial inclusion is lacking. This is partly because, until recently, consistent macro data on financial inclusion across countries were scarce. Moreover, with a few

exceptions, this topic was not on the radar of mainstream macroeconomists until the 2008 U.S. subprime crisis (Sahay et al., 2015b).

Over the past few decades, there has been a growing interest in the direction of innovation towards the needs of the disenfranchised population and low-income consumers—inclusive innovation or inclusive growth—particularly in low and middle-income countries (Bell and Figueiredo, 2012; George et al., 2012). Pursuing inclusive innovation is one of the conditions for building inclusive innovation systems that promote business profitability and the generation of social well-being (Foster and Heeks, 2013; Morales et al., 2023).

The inclusive direction of innovation is closely related to financial inclusion because it advocates for a more equal and fair distribution of the economic benefits of innovation and economic growth, evoking concepts of social justice and equity (Altenburg, 2010; Pansera and Owen, 2018). When adequately implemented, inclusive innovation can bring positive benefits to underprivileged communities, such as reducing malnutrition, generating employment, developing human capital, and bringing dignity to their members (Peerally et al., 2019). Thus, by attempting to reduce the inequality-increasing effects of innovation (Schillo and Robinson, 2017), inclusive innovation responds to the perception that, oftentimes, the innovation process is a mere contributor to increasing social exclusion and the economic divide (Pansera and Owen, 2018).

Inclusive innovation may occur in various industries, including finance, where financial innovation has been under significant criticism since the start of the subprime crisis in 2008. So

much so that financial innovations, such as subprime securitizations and credit default swaps (CDS), have primarily become stigmatized among many who believe these types of innovation are detrimental to consumers and the financial system. Norden et al. (2014) assert that there is still no consensus in the literature on whether the impact of financial innovations on the financial system is beneficial. A concern was also expressed by Cong et al. (2023), who demonstrated that digitization and decentralized finance (DeFi), if not well-designed, can further exacerbate the digital divide. Paul Volcker, former chair of the Federal Reserve, was skeptical about novel financial innovations and claimed there was no clear evidence that financial innovation had led to economic growth. This controversial point of view was also shared by Paul Krugman, winner of the Nobel Memorial Prize in Economic Sciences, who argued that some of the most recent financial innovations spread confusion and lured investors into taking on more risk than they realized (Allen, 2012).

Nevertheless, over the last few years, the emergence of technology-enabled innovations in financial services, also known as financial technology or just fintech[1], has gained increasing global attention as a potential instrument for financial inclusion and socio-economic development, suggesting that it is possible to reconcile the inclusive direction of innovation and financial advancements (Siqueira et al., 2018). A relevant example is the Bali Fintech Agenda, launched by the World Bank Group and the International Monetary Fund in 2018 (International Monetary Fund (IMF), 2018). With the transformation of finance brought about by technology, the Bali Fintech Agenda recognizes the need for regulators and policymakers to actively engage

[1] For the scope of this research, fintech innovation, including online banking, crowdfunding and P2P lending, encompasses both innovative fintech startups, as well as the expansion of technology giants into the financial services space (Cumming et al., 2023).

in domestic policy discussions to harness new efficiencies and opportunities to broaden financial access and achieve financial inclusion while safeguarding financial stability and consumer protection (Pangestu, 2023).

In fact, few issues in financial innovation have generated more hype—and confusion—in recent years than fintech. Although technology has long played a key role in finance, recent fintech developments have generated disruptive innovation in data collection, processing, and analytics, which has helped introduce new relationship models and distribution channels that challenge traditional ways of finance (Consultative Group to Assist the Poor (CGAP), 2022; Granja et al., 2022; Tan et al., 2024). These developments have attracted researchers' attention to the outcomes of fintech innovation from different standpoints.

On the one hand, some researchers have pointed out that fintech can promote access to finance and offer unparalleled opportunities for the low-income population (McKinsey Global Institute, 2016; Natile, 2020). Cong et al. (2023) highlight that recent financial innovations have improved financial inclusion through redistributing on-chain income and wealth across network nodes. A recent study published by the World Bank indicates that financial technology supports growth and poverty alleviation by fostering financial development, inclusion, and efficiency and providing the financial services required for the digital economy to expand (see Feyen et al., 2023).

On the other hand, this excitement around fintech has also masked the additional risks it poses to marginalized segments of the population and the financial system's stability. Cumming et al.

(2023) have raised concerns about the potential of the growing prevalence of fintech innovation for data breaches, unauthorized access to sensitive information, financial exclusion, and discrimination. Fang et al. (2023) argue that the growth in financial technologies has been associated with greater bank risk-taking. Using country-level data, Cevik (2023) shows a negative impact of fintech on financial stability. While most of these risks are not new, their effects and how they materialize and spread across the financial system are not yet fully understood, posing new challenges to regulators and supervisors (CGAP, 2022; World Bank, 2022b).

Other studies have investigated the impact of fintech innovation from different perspectives. Li et al. (2022) and Geng et al. (2023) studied the effects of bank fintech from the standpoint of stability in China. Zhao et al. (2022) examined the impact of fintech innovation on Chinese banks' performance. In contrast, Li et al. (2023) discussed the moderating effect of the attention of external stakeholders like investors and customers on the relationship between regional fintech growth and corporate green innovation in China. Through a systematic literature review, Gangzyk et al. (2022) analyzed the role of governance as a mediator between fintech and socio-economic outcomes in a geographical context, and Mertzanis (2023) explored the effects of aggregate country values of fintech finance on countries' environmental performance.

However, despite the volume of studies on fintech innovation and its outcomes, there are opportunities for novel systematic analyses to further our understanding of the interrelationship between fintech innovation, financial inclusion, and the stability of the financial system and fill in some relevant research lacunae. Firstly, prior studies on fintech and its implications for

financial stability are ambiguous and present mixed results on whether fintech is a threat or an opportunity to achieve financial health, especially for destitute individuals (Feyen et al., 2023; Fung et al., 2020). Moreover, most extant studies analyze either the relationship between fintech innovation and financial stability (e.g., Cevik, 2023; Daud et al., 2022) or that between financial inclusion and stability (e.g., Danisman and Tarazi, 2020; Hua et al., 2023) but do not investigate their interrelationship deeply.

Secondly, a more holistic view of fintech innovation means that understanding the stage of individual-level financial capability-building initiatives (Demirgüç-Kunt et al., 2022; Lusardi and Mitchell, 2014) and regulatory and supervisory frameworks (Arner et al., 2020; Sahay et al., 2015b) in the fintech landscape is essential to a more accurate theory of its country-level stability outcomes. Unfortunately, despite a few exceptions (e.g., Gancarczyk et al., 2022), existing literature has devoted little attention to the contexts in which financial capabilities and regulation and supervision play critical roles in the abovementioned interrelationship. Thirdly, most extant studies tend to rely on data on specific countries or regions (e.g., Banna et al., 2022; Geng et al. 2023; Suri and Jack, 2016), limiting the literature's empirical basis for external validation and theoretical inferences regarding causal effects on stability.

To explore the aforementioned research gaps, we firstly provide an up-to-date, integrated, and critical literature review of the research on fintech-driven financial inclusion, which identifies emerging themes, explains existing contributions, and highlights inconsistencies. Then, we use a Generalized Method of Moments (GMM) balanced panel with 82 countries from 2013 to 2021 to estimate the impact on the financial stability of the unprecedented spread of fintech innovations

worldwide in the past few years. In addition, we suggest directions for future studies to investigate these issues further.

By doing so, our study adds to the manifold literature on financial innovation and technological innovation in at least four important ways. Firstly, our study proposes and empirically tests a conceptual model of the effects of fintech adoption on financial deepening and financial stability. Our empirical tests contribute to elucidating the potential of fintech innovation to bring financially excluded people into the formal financial system and the influence of such inclusive and financial innovation on financial stability.

Secondly, our theory and findings contextualize fintech innovation by showing how individuals' financial capabilities and regulatory and supervisory frameworks are critical to its stability effects. Specifically, our results suggest that countries that want to benefit from fintech innovation must skillfully navigate the level of financial capability-building initiatives and regulatory and supervisory frameworks in their fintech landscape development. Our study attests that the link between fintech innovation and financial stability is more complex than previously assumed. It also suggests that the prospective gains from fintech adoption are conditional on appropriate financial capabilities and balanced regulatory and supervisory frameworks.

Thirdly, we contribute to the related literature by deepening the understanding of the financial stability implications of fintech innovation. Contrasting with the current empirical literature on fintech-driven financial inclusion, our comprehensive approach with wide geographical coverage and reliable datasets ensures the representation of a diverse range of countries and financial indicators, presenting a valuable contribution to expand research on the advent of financial

innovation and its interaction with technological innovation and economic development around the world.

Finally, our results suggest that the inclusive direction of innovation (Bell and Figueiredo, 2012; Morales et al.'s, 2023; Pansera and Owen, 2018) can benefit from fintech adoption as long as adequate regulation and supervision and effective individual financial capability-building programs are in place. Our study contributes to helping policymakers manage the long-standing risks and maximize the economic and social benefits of fintech innovation. We argue that striking the right balance between trade-offs at every step of fintech development remains essential to promoting innovation while controlling financial risks. Thus, our study has the potential to influence the design, modification, and implementation of corporate strategies and public policies to increase fintech innovation and financial inclusion without adding additional risks to the financial sector's stability.

The remainder of this thesis is as follows: In Section 2, we review the relevant literature to contextualize the analysis and present our four hypotheses to be tested. In Section 3, we describe the datasets and variables and introduce the estimation strategy used in the study. In Section 4, we provide the results. Section 5 examines the validity of our hypotheses and discusses our contributions to financial innovation and technological innovation research, while Section 6 concludes the study.

2 – THEORETICAL BACKGROUND AND HYPOTHESES

2.1 - Literature search and screening process

Our search strategy consisted of searching for relevant scientific and gray literature studies. The main stages of the screening process are shown in Figure 1. The initial literature scoping helped us identify keywords and search strings related to fintech innovation and financial inclusion. We used the Scopus database complemented by the Social Sciences Citation Index (SSCI) from the Web of Science. Using these two databases increased the validity of our approach by providing comprehensive coverage of high-impact, peer-reviewed journals without being limited to a specific research area. A supplementary, multi-layered strategy was used to search the gray literature, which included obtaining expert recommendations, snowballing, cross-referencing, and online technical and specialized databases selected for reputation, currency, authority, and search functionality (e.g., World Bank, International Monetary Fund - IMF).

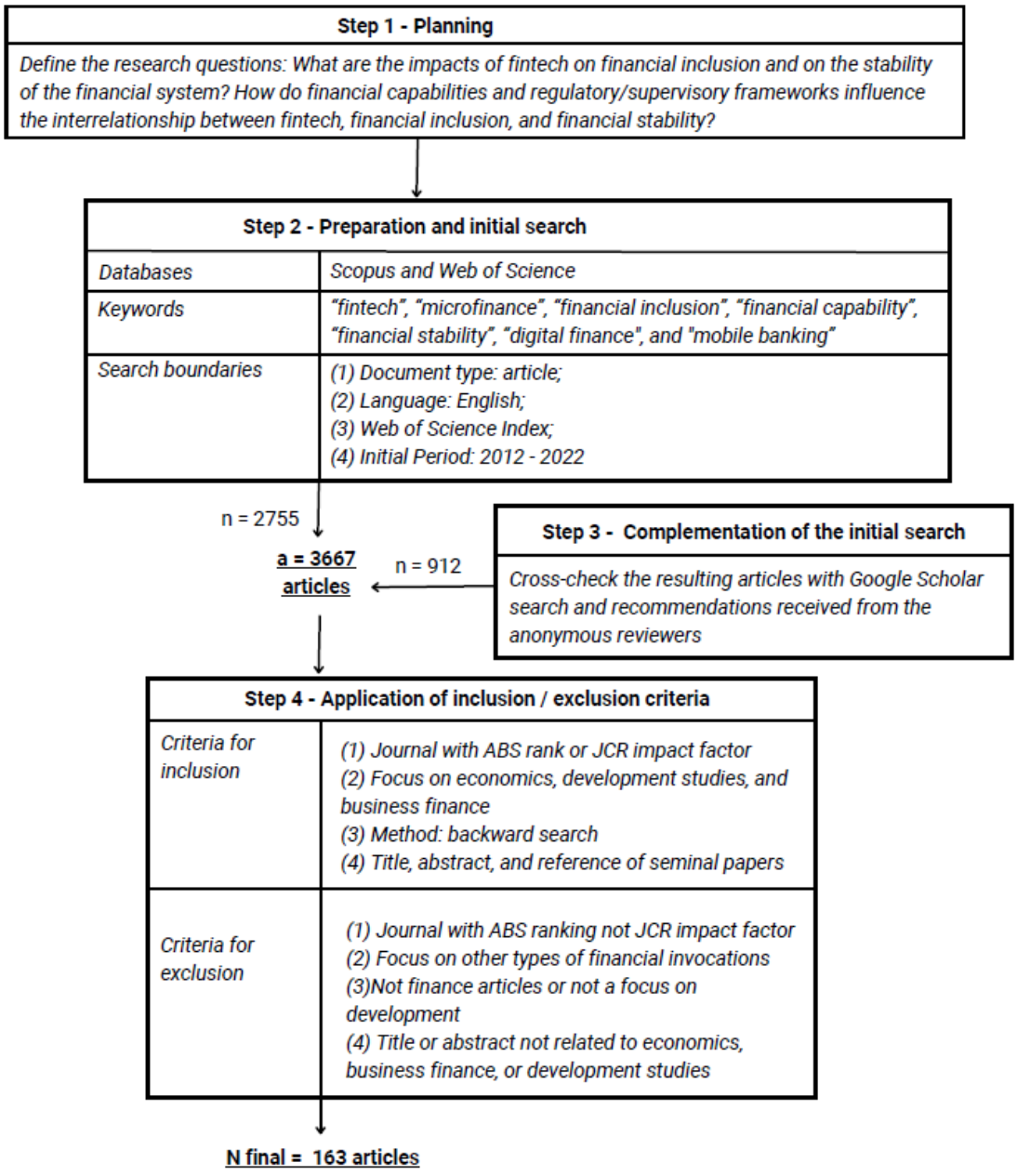
The sources for the literature review include peer-reviewed articles, newspapers, magazines, and books. We accessed one of the world's leading citation databases by collecting citation data compiled by the Institute for Scientific Information's Web of Science Trademark Core Collection. We also used the guidelines for a systematic literature review described by Budgen and Brereton (2006), Hoon (2013), Liu et al. (2020), and Sarkar and Mateus (2022) to search for relevant papers. Choosing the systematic review method enabled us to examine the topic from various perspectives based on existing literature. This method involves reviewing current

research publications that are relevant to the topic and serve as a reliable source of evidence-based information that can be used to analyze the topic.

Having framed the research gaps in the literature (Step 1: planning), we proceeded with our preparation and initial research (Step 2) by identifying the appropriate string of keywords. The search terms used to identify relevant literature were derived from an iterative process of searching and discussing by the two authors of this study. Based on the definition of financial inclusion and fintech, the publications retrieved for sampling in this study are restricted to subjects containing the terms “financial technology,” “fintech,” “microfinance,” “financial inclusion,” “financial capability,” “financial stability,” “digital finance,” and “mobile banking” in the Web of Science’s core collection database.

Because not all papers in the search were necessarily related to the topic of the literature review, these references had to be evaluated for their relevance (Budgen and Brereton, 2006). The retrieved articles were then screened in scientific databases using a search protocol. To filter out relevant articles, we applied the data-filtering process proposed by Liu et al. (2020). Only English-language articles published in the last ten years were considered at this study stage and 2,775 references were included using the keywords.

Figure 1. The main steps of the screening process



Source: Adapted from Sarkar and Mateus (2022).

To ensure that our review was comprehensive and did not exclude relevant articles, our search was further complemented by cross-checking the results list using Google Scholar searches (Step 3) (Owalla et al., 2022; Sarkar and Mateus, 2022). A review update was carried out in addition to a systematic search to identify articles published after our initial search or those the review might have missed. This comprehensive approach included searches on Google Scholar and further searches later. The narrative search yielded a total of 912 articles.

Next, in Step 4, we used specific inclusion and exclusion criteria to screen the retrieved papers. Our study focuses on finance, innovation, and development. Finance and Economics are related disciplines that often overlap. Both disciplines work together to complete each other. Therefore, only full-text articles on economics, development studies, or business finance were considered. We searched for articles published in relevant journals on economics, innovation, business finance, and development studies and found 313 articles.

The papers were screened based on their titles, and those irrelevant to the research topic were excluded. However, determining the relevance of an article only based on its title is often difficult. Thus, the paper was passed on to the next stage of further reading. Subsequently, the abstracts of every article that passed the previous steps were read. References to seminal papers, particularly those relevant to this literature review, were also considered (backward search) to improve the quality of the research.

Among the 313 retrieved papers, 163 economics, business finance, innovation, and development studies closely associated with fintech, financial inclusion, and financial stability were selected for the literature review. Although we initially included only studies published in the last 10 years, a backward search also looked for references published in previous decades. Of the 163 articles selected, 27 were published before the 10-year study period.

2.2 – Review of empirical studies and theoretical background

The purpose of this section is to develop a brief review of relevant empirical studies concerning financial inclusion initiatives, fintech innovation, and the stability of the financial system with the aim of building relevance to the proposed themes. This review gathers studies performed in advanced and developing economy contexts that unveiled elements that influence both frugal and financial innovations. Besides discussing the merits and limitations of such studies, this chapter provides the theoretical basis against which the research gaps will be explored in the field research. Specifically, it aims to explain the main concepts presented in the research hypothesis.

2.2.1 Inclusive innovation and financial innovation

From a Schumpeterian standpoint, innovation is a new combination of knowledge, capabilities, skills, and resources reflecting an organization's competitive advantage (Fagerberg, 2005). It delivers a quality jump and takes a saturated economy to a new level of productivity. Put

differently, innovation is a critical factor in economic growth and social change. It presents as a sine qua non to narrowing the economic gap between advanced, middle, and low-income countries (Lee, 2013, 2024).

However, we must remember that any innovation effort is also a function of appropriability conditions. With very low appropriability of the potential economic benefits, an organization or entrepreneur would have a very small incentive to innovate, even with the existence of significant technological opportunities. Nonetheless, if the appropriability is excessively high, only a tiny share of the potential benefits of innovation could be spread throughout the economy (Dosi, 1988).

Also referred to as frugal innovation (The Economist, 2010), inclusive innovation is the process of redesigning products and rethinking the entire production processes and business models. It means employing technological capabilities to establish unique competitive positions in low-income markets with new products that are less technologically sophisticated than equivalent ones produced in developed economies (Bell & Figueiredo, 2012). Inclusive innovations can contribute to sustainable development by offering to disadvantage segments of the population the possibility of acquiring products that really fit their needs, reducing the usage of natural resources, and creating inclusive economic growth through the participation of local communities in the value chain. Inclusive innovation highly depends on the contribution of underprivileged community members. In order to provide novel solutions to complex problems and generate change at the social level, inclusive innovation initiatives need the engagement of

vulnerable populations not only as beneficiaries but also as active participants and contributors (Peerally, De Fuentes, and Figueiredo, 2019).

Frugality is not an absolute all-or-nothing concept but a matter of degree and interpretation, like inclusion or sustainability. Thus, frugal innovations do not necessarily mean an automated contribution to inclusive or sustainable development. Other driving forces might contribute to longer-term developmental solutions for impoverished communities. The interactions between many and diverse actors of innovation in various configurations at different levels play a crucial role in promoting those solutions. Frugal innovations are usually the result of locally embedded practices and adaptive strategies of local entrepreneurs or firms, NGOs, or even international corporates trying to profit from the base of the pyramid. That is why, oftentimes, issues related to power and conflict of interest deeply affect how such innovation practices impact people's lives (Knorringa & Leliveld, 2018). Hence, it is essential to understand who contributes to and benefits from the new opportunities that inclusive innovation is bringing so as to assess its transformational potential appropriately and, thus, put in place measures that lead to an efficient diffusion of innovation initiatives and a fair distribution of the produced economic benefits.

In his book "Diffusion of Innovations," Professor Everett Rogers (2003) discusses the regularities in the diffusion of innovations, patterns that have been found across cultures, innovations, and the people who adopt them. The diffusion of innovations explains social change, one of the most fundamental human processes. Since then, there has been a significant amount of interest across fields in what drives the adoption of innovations across cultures and

over time. Scholars seek to provide answers to the question of what drives the adoption of innovation in resource-limited settings. However, seldom does research focus on how consumers use the product or service and the impact that this use has on individual and community well-being. In the context of inclusive growth, the effect of product use is as essential as adoption.

The rapid diffusion of information and communications technology (ICT) paves the way for low-cost innovations by users that can be of high value and significantly increase the usage of the underlying technology. The Noble Peace Prize winner Muhammad Yunus (2007) claims that ICT is changing the world more rapidly and fundamentally than any other technology before, being particularly beneficial to minorities and disadvantaged groups who are excluded from the financial system. Since for-profit, mission-driven fintech players promise to develop and provide ground-breaking financial products and services for underprivileged populations living on low incomes, fintech can be considered not just as a financial innovation but also as an inclusive innovation to enable more equal and fair distribution of the benefits of innovation and economic growth and to foster social justice and equality (Pansera and Owen, 2018).

However, we should bear in mind that although some technology-based initiatives seem inclusive innovation at first glance, they are indeed examples of mere "solutionism." Evgeny Morozov (2014) claims that “technological solutionism” is an endemic ideology that recasts complex social phenomena, such as education and poverty, as neatly defined problems with concrete solutions or as transparent and self-evident processes that can be easily optimized.

Complex social issues cannot be overcome only through solutions based on technology in "autopilot mode."

Therefore, so as to put forward the appropriate strategies to achieve sustainable development goals, it is critical to distinguish inclusive innovation from solutionism approaches that only consider the top of the iceberg of the problem and might even lead to new problematic situations. Put differently, inclusive innovation does not mean encouraging more consumption. On the contrary, since high-cost intensive innovations tend to exclude the needs and desires of lower-income people, frugal innovations can assist in overcoming the constraints of conventional welfare systems by alleviating poverty, as opposed to incentivizing consumerism of low-quality products or services. Hence, in order to be an actual inclusive innovation, fintech should be a mechanism for creating reasonable offerings for marginalized segments of society, providing good enough financial products and services that are affordable and meet the demand of those low-income consumers.

2.2.2 The fintech revolution

A fundamental challenge in studying fintech innovation is that currently there is not a standard definition of what “fintech” is and what specific technologies the term entails (Chen, Wu, and Yang, 2018). It has been defined in various ways by different scholars and practitioners, reflecting the diverse and rapidly evolving nature of the field. However, while these definitions may vary in their scope and focus, they all convey the primary goals of fintech innovation, which

are to enhance efficiency, accessibility and affordability of financial services (Cumming et al., 2023).

In that sense, fintech, as the name suggests, is about introducing new technologies into the financial sector and encompasses both digital and technology-enabled business model innovations (Wang et al., 2021). The Bali Fintech Agenda, the Financial Stability Board (FSB), and others broadly define fintech as “advances in technology that have the potential to transform the provision of financial services, spurring the development of new business models, applications, processes, and products” (International Monetary Fund (IMF) 2018: 12).

The terms "digital finance" and "fintech" both refer to the changes happening in the financial industry due to the use of information and communication technologies, but they have slightly different meanings. Digital finance focuses on how financial services are becoming more digital and can be the method for extending financial integration of the people excluded from the formal financial market (McKinsey Global Institute, 2016), while fintech refers to the use of digital technologies to enable, innovate, or disrupt commercial activities in finance (Zou et al., 2023).

The intersection between innovation, development, and poverty alleviation is attracting the interest of an increasing number of scholars in the fields of business, management and research, and innovation policy (Pansera & Owen, 2018). Mobile banking services offered by fintech firms are now combining innovative mobile technologies and smart financial services to provide convenient and flexible access to banking systems through portable smart equipment, helping underprivileged and rural populations overcome problems due to remoteness and reduce the high

costs of remittances' transfers (Ezzahid and Elouaourti, 2021; Yaseen et al., 2022). Some studies (Fall et al., 2020; Siano et al., 2020; Uwamariya et al., 2019) suggest that mobile banking represents a key vector of financial inclusion in many developing countries, especially in sub-Saharan Africa, and allows for reducing transaction costs and loan defaults and thereby increases the efficiency of MFIs.

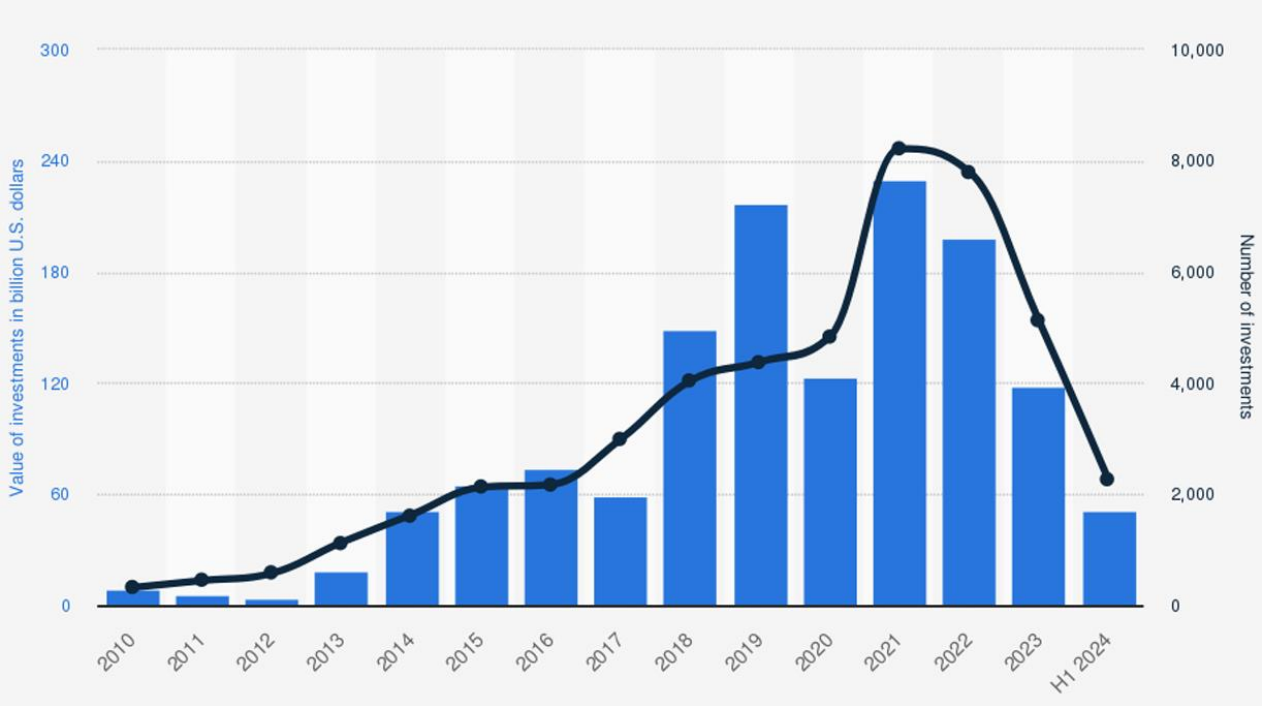
Some scholars argue that the emergence of fintech has been triggered by the loss of trust in central banks and the financial system[2]. It is no coincidence that fintech came into prominence following the global financial crisis of 2008 (Goldstein, Jiang, and Karolyi, 2019; Prasad, 2019). For instance, peer-to-peer lending platforms are often regarded as having filled market gaps left by banks' micro, small, and medium enterprises (MSME) lending retrenchment after the global financial crisis (Beck, 2020). The Great Recession dramatically affected the trust that the young generations place in banks, which has afforded startups the opportunity to exploit banks' severely damaged reputations (Di Maggio, 2021). The decreased trust in incumbent financial institutions in the wake of the Financial Crisis, combined with the rise in usage of mobile technologies, represented an ideal entry point for tech firms offering financial services by way of smartphone apps and other technologies (Chemmanur et al., 2020). Since trust exerts a positive and statistically significant bearing on financial inclusion in terms of both ownership and use of financial products and services (Ghosh, 2021), fintech is likely to become a real game-changer in financial inclusion provided robust consumer protection and data privacy guidelines are in place in order to enhance households' and businesses' confidence.

[2] Globally, 16% of adults exhibit distrust in the financial system, with the proportions being much higher in developing countries (Ghosh, 2021).

This newly emerging technology has the potential to radically transform financial services by making transactions less expensive, more convenient, and more secure (Chen, Wu, and Yang, 2018). According to KPMG (2024), the total value of fintech investments worldwide saw a dramatic rise from 2010 to 2019, peaking at US$ 216.8 billion. In 2020, investments dropped sharply to below US$ 124 billion but rebounded in 2021 to over US$ 229 billion. 2022 experienced another decline, though not as severe as 2020. The downward trend continued in 2023, with global fintech investments reaching US$118.2 billion (Figure 2). A combination of global challenges, including high interest rates and persistent inflation in many countries, conflicts in Ukraine and the Middle East, coupled with declining valuations and a subdued exit landscape, led to a growing sense of caution among fintech investors. A shift toward profitable and sustainable business models will be fundamental for fintech firms to thrive in the long run (The Banker, 2024).

However, if we are really witnessing the “fintech revolution”, the question is to what extent is this revolution different from previous interlinkages of finance and technology? Some researchers claim that the three fundamental changes that have differentiated the current fintech revolution are massive data generation, advances in computer algorithms, and increases in processing power (Gomber et al., 2018; Sahay et al., 2020). These advancements have been facilitated by an unprecedented speed of technological development, including high-speed broadband internet, cloud computing, storage technologies, and artificial intelligence, which have enabled big data analytics, blockchain technology, and biometric identification (Arner et al., 2020; Sahay et al., 2020).

Figure 2. Global fintech investments, 2010 – H1 2024



Sources: adapted from Statista Research Department data, 2024 (https://www-statista-com.sbproxy.fgv.br/statistics/719385/investments-into-fintech-companies-globally/)

The Economist (2015) described this disruption in finance as “the fintech revolution” – an unprecedented combination of young ICT professionals and venture capital disrupting the financial service industry. The article argued that fintech firms can reshape finance and improve it in three fundamental ways: cutting costs and improving the quality of financial services, adopting clever new ways of assessing risk and creating a more diverse, hence stable, credit landscape.

Since low-ticket clients/transactions are typically associated with informational inefficiencies, with most clients unable to produce any collateral or to provide an adequate track record of repayments (Khan, 2012), one of the biggest challenges faced by inclusive innovations is how to marry profits with social goals. That is why business activities need to insert neglected and underprivileged communities into efficient value chains and market structures if they aim to contribute to the long-term goal of poverty reduction (Knorringa & Leliveld, 2018). Leite, Mendes, and Sacramento (2019) contribute to the discussion of sustainability and mission drift of financial inclusion institutions by investigating whether microfinance institutions' (MFI) profit orientation determines some differences regarding sustainability and revenues. The unprecedented expansion of MFI, both in terms of size and complexity, raises the discussion on whether financial innovation initiatives are indeed sustainable in the long run (Leite, Mendes, and Moreira, 2020). Guzella, Fernandes, and Oki (2023) address the problem of lack of capital for projects that combine profitability with sustainable outcomes by investigating whether innovative financial instruments – impact bonds can be useful for funding promising initiatives and better-aligning stakeholders' incentives.

Yunus (2007) labels 'social consciousness' the attitude demonstrated by organizations, such as the Grameen Bank, that are driven by social goals and can be formidable competitors for greed-based enterprises. The author put forward that societies replace the profit maximization principle with a generalized one, compounded by positive profit and social returns. With a similar perception regarding fintech, Siqueira, Diniz, and Gonzalez (2018) coined the term "social fintech" or "socialtech" as a financial startup operating on digital platforms that uses digital platforms to deliver innovative financial services seeking to generate social impact. Socialtech

firms, like other microfinance institutions, are technological startups that deliver financial services, and social enterprises, as they seek to reconcile their social mission with the economic sustainability of their activities.

Despite the widespread interest in fintech, there is still little research on the occurrence of fintech innovation and the value that it can bring to disadvantaged segments of the population (Lagna & Ravishankar, 2022). A major limitation of the current literature on financial technology and financial inclusion, however, is its narrow focus on certain financial products and countries, which raises questions about the generalizability of their findings. Moreover, while some fintech providers have been successful in addressing financial inclusion, little is known about how and why those fintech firms achieve this outcome, whereas others fail to do so (Senyo & Karanasios, 2020). Thus, more research is needed on the fintech-financial inclusion nexus that goes beyond the current focus on certain technologies and regions (Demir et al., 2022).

Modem financial theory emphasizes the intermediation role performed by financial institutions in bridging borrowers and savers, thereby performing the functions of savings mobilization, capital fund allocation, monitoring of the use of funds, and managing risk, which together support the economic growth process (Jalilian and Kirkpatrick, 2005; Levine et al., 2000). However, the effective use of finance can be hampered by the information asymmetry between financial institutions and underserved consumers[3], an imbalance that holds real potential for negative outcomes due to institutional abuses and ill-informed client decisions (Cohen and

[3] In information asymmetry, one member is equipped with more information than the other, causing a power imbalance in transactions that leads to inefficiency and market failure (Akerlof, 1970; Mhlanga, 2021).

Nelson, 2011) caused by the lack of financial capabilities. High fixed transaction fees and other transaction-related issues also preclude financial democratization and inclusion (Cong et al., 2023).

Fintech has gained increasing global attention as a promising tool to reverse this trend by promoting financial inclusion and socio-economic development (McKinsey Global Institute, 2016; Natile, 2020). The availability of capital and the development of financial markets set the stage for fintech to provide financial intermediaries with better technology to screen information and, therefore, improve resource allocation efficiency and alleviate information asymmetry (Laeven et al., 2015; Yuan et al., 2021).

Financial innovations have a key role in developing instruments to make investment opportunities with higher expected returns and positive sustainability impact more attractive or compatible with investors' expectations or preferences (Guzella, Fernandes, and Oki, 2023). Fintech innovations promise to leverage alternative data derived from unbanked individuals' behavioral patterns—such as their use of mobile phones or social media—to create algorithms that assess their creditworthiness (Gabor & Brooks, 2017; Lagna & Ravishankar, 2022). Innovative fintech firms are implementing a more simplified and effective screening process, helping borrowers, especially women, obtain larger loans with smaller interest rates, which may contribute to reducing the "collateral gap" between genders in low-income countries (Leite, Mendes, and Camelo, 2024). Since these data are less structured than traditional ones (e.g., FICO) and many potential borrowers are not properly scored by traditional methods, fintech

firms often rely on ML algorithms to exploit these alternative sources of information effectively (Philippon, 2019). By capturing nonlinearities in the relationship between the credit risk outcome and features, ML is capable of better assessing the borrowers, particularly those with poor credit history. Thus, fintech providers can mitigate financial exclusion due to information asymmetry by identifying indicators of borrower riskiness through analyzing larger data and identifying differences among borrowers (Bazarbash, 2019).

Goldstein et al. (2019) argue that this fintech revolution is unique in that much of the change is happening from outside the financial industry as young start-up firms and big established technology firms are attempting to disrupt the incumbents, introducing new products and technologies and providing a significant new dose of competition. Applying technological advances, in conjunction with financial innovation, can provide financial services that ultimately alleviate fixed-cost constraints and frictions related to transaction costs and incomplete information. Fintech innovation can lower transaction costs by overcoming geographical access barriers, increasing transaction speed, security, and transparency, and allowing for more tailored financial services that better serve consumers, including low-income people. Moreover, fintech innovation can also enhance transparency and reduce information asymmetries since digital processes generate a data trail, which can be used to understand consumers better, improve products, manage risks, and promote regulatory compliance (Feyen et al., 2023).

However, even though fintech has the potential to promote financial inclusion and socio-economic development, some authors (e.g., Lagna and Ravishankar, 2022; Philippon, 2019)

argue that the so-called “fintech revolution” should be viewed with caution. They shed light on the dominant narrative depicting fintech as the new panacea for poverty reduction, financial inclusion, and local development. Their research suggests that apart from creating significant privacy, regulatory, and law-enforcement challenges, fintech could increase the scope for some forms of discrimination or exacerbate inequality. Other authors (e.g., Bateman et al., 2019; Ozili, 2020c) claim that digital finance reinforces the existing inequality in the financial system, which worsens the state of underprivileged people. As argued, exposing the poorest to the formal financial system will subject them to serious risks. Some of those risks include fraud risk, lack of access to internet connectivity, systematic risks, technology and infrastructure risks, loss of trust, and no clarity on who protects underprivileged consumers from digital risk, transferring old risks to new customers.

Although, in the fintech era, the use of ML can improve credit market efficiency without increasing unwarranted human biases against minorities (Tantri, 2021), discrimination is still a cause for concern among scholars and policymakers since ML could inadvertently introduce new forms of discrimination or reactivate old ones (Philippon, 2019). As highlighted by Cathy O’Neil (2017) in her seminal book “Weapons of Math Destruction,” the mathematical models being used today are highly unregulated and might even reinforce discrimination. In that sense, Sahay et al. (2020) argue that the use of big data analytics could become a source of financial exclusion if the initial data entry is biased or if algorithms are imperfectly calibrated. Furthermore, self-learning algorithms may even enhance biases existing in the data, which explains why providers should constantly test the outcomes of algorithmic data interpretation (Arner et al., 2020).

Bateman, Duvendack, and Loubere (2019) argue that some studies about fintech (e.g., Suri & Jack's, 2016) have been sponsored and widely promoted by important organizations, such as the Gates Foundation, that are not neutral observers concerning the fintech movement. In that sense, self-censorship of impact results that produce findings that are comforting to elite donors might be a cause for concern since this practice is pervasive in much of the academic economics and impact evaluation communities. The authors conclude that fintech, more generally, is a financial innovation that enriches elites at the expense of impoverished people while also shifting risks to the poor themselves, ultimately ensuring that it is the poor that will be the ones most devastated by a possible future financial bubble.

Fuster et al. (2019) point out that fintech companies do not actually target potential clients with low access to traditional finance, which suggests that they are primarily competing with conventional finance providers rather than broadening access. Lagna & Ravishankar (2022) also assert that, since the products and services offered by fintech providers are chiefly designed for banked customers, fintech can even aggravate inequality by offering financial solutions only available, perceived, or comprehended by the wealthy and middle classes. Moreover, Wyche, Simiyu, and Othieno (2016) claim that even when fintech firms target underprivileged customers, the development gains are modest, and the real impact of such technology on the livelihoods of low-income communities is still not clear.

It is fair to say that the extent to which fintech could put financial inclusion itself at risk has been much less explored to date (Sahay et al., 2020), which suggests that more data and impartial

research are needed to examine the effects of fintech on financial inclusion (Čihák & Sahay, 2020). Thus, one question that springs to mind is whether fintech is broadening financial inclusion or only providing alternative means of access to those already financially included. Furthermore, the question of whether fintech algorithmic decision-making promotes or inhibits discrimination is especially relevant in the context of providing financial assistance, given both the historical challenge of eliminating discrimination in this domain and the importance of financial inclusion for the well-being of underprivileged households. Although fintech has been publicized as a means to democratize access to financial services, it is possible that, in fact, fintech is increasing discrimination and financial exclusion, which has serious consequences for already marginalized segments of society.

Furthermore, fintech firms are facing their own challenges. According to the Economist Intelligence Unit Limited (EIU) (2022) – the research and analysis division of the Economist Group, fintech companies – the upstart rivals of the incumbents of the financial industry, are likely to fail in large numbers due to a funding drought. This is because of the tighter lending conditions on a global scale due to high-interest rates. Since fintech companies generally have a more limited range of activities, unlike incumbent financial firms, they are much more vulnerable to those financial conditions. In fact, the current capital-market crunch may hobble a wide variety of loss-making fintech challengers that sought to outflank incumbents in banking, payments, and other activities. Furthermore, according to the World Bank, the financial industry is rapidly boomeranging toward the concentration of players and platforms because of the economies of scale and the massive amounts of data held by Big Tech companies (Feyen, Natarajan, and Saal, 2023). In some developing economies, we observe a process called by

Moraes et al. (2024) "*fintechrization*" – an innovative solution to fill institutional gaps in the financial market. It represents the process of creating fintechs by companies established in non-financial sectors, especially large retailers, to serve their share of customers not assisted by financial incumbents and fintech startups.

Nonetheless this daunting financial scenario with high inflation and high-interest rates, most financial firms are likely to enjoy a tailwind from citizens' rapidly rising use of formal financial services, increasing needs for savings for aging populations, and the huge financing needs for policy objectives such as decarbonization and infrastructure improvements. A shift to digital strategies focused on mobile and online services will allow firms to close physical locations and trim staff expenses. It is predicted that, in the longer term, the financial industry will benefit from enduring trends toward greater use of digital services, improved financial inclusion, and expanding needs for savings to cover aging populations and investment to confront challenges like the green transition (EIU, 2022).

2.2.3 Fintech and financial stability

The rapid development of fintech and its multiple interconnections with traditional financial institutions have led to a debate on its effects on financial stability and market volatility. However, the existing literature on fintech and risk spillovers in the financial system is still at an early stage and inconclusive. Norden et al. (2014) emphasize that the costs and benefits of financial innovations are a hotly debated topic among scholars and practitioners, and there is no

consensus yet about whether the influence of financial innovations on the financial system is broadly a positive one. Daud et al. (2022) also highlight that very little research explicitly addresses whether the rise of fintech disrupts financial stability.

Becket al. (2016) presented the ‘innovation-growth’ and ‘innovation-fragility’ perspectives theorising that financial innovation either has a positive or negative economic impact on financial systems. The traditional ‘innovation-growth’ view posits that financial innovations improve the functions of the financial system as they facilitate risk sharing (Allen and Gale, 1994), complete the market (Elul, 1995; Grinblatt and Longstaff, 2000), improve allocative efficiency (Houston et al., 2010; Ross, 1976), and improve the quality of financial services (Wang et al., 2021). On the other hand, the ‘innovation-fragility’ view puts forward the idea that financial innovations, such as fintech and bigtech, could increase risks by amplifying contagion, procyclicality, and volatility in the market and undermine the stability of the financial system, which might ultimately cause a financial crisis, like the 2008 sub-prime crisis (Adrian and Brunnermeier, 2016; Brunnermeier, 2009; Fung et al., 2020).

Contributing to the ‘innovation-growth’ view, Wang et al. (2021) claim that the development of fintech has resulted in increased profitability, financial business innovations, and improved risk control for commercial banks, contributing to the financial system's stability. Daud et al. (2022) investigate the effect of fintech on financial stability considering the role of competition/concentration. The authors employ a model derived from the Schumpeterian finance-economic development theoretical view where innovation, competition, and economic

dynamics are combined in one system. Their results suggest that fintech is positively and significantly correlated with financial stability and greater concentration leads to an improved fintech–stability relationship.

From the ‘innovation-fragility’ perspective, Lee et al. (2021) highlight that financial innovation might encourage large institutions to profit from high leverage and destructive spillovers, which affects concentration and risk in the financial system. Cevik (2023) claims that fintech could become vulnerable to cybersecurity risks, amplify market volatility, compound aggregate risk-taking and contagious behavior among consumers and financial institutions, and undermine financial stability. Li et al. (2020) claim that the risk spillover from fintech to traditional financial institutions has a positive relationship with, and could even be a potential cause of, the systemic risk of traditional financial institutions.

Moreover, the competition from bigtech and fintech entrants may incentivize incumbent financial institutions to increase risk-taking to preserve market share and profits (FSB, 2022), which can seriously damage financial stability. While incumbents initially viewed the rise of fintech firms as a threat to their existence, they have been quick to respond with their own digital financial services and partnered with fintech start-ups (Senyo and Karanasios, 2020). Fintech can also constitute a threat to the financial system through cybersecurity risks, new money laundering/terrorism finance risks, or inappropriate lending practices by underregulated institutions, which can ultimately jeopardize trust and, therefore, erode financial stability.

Consumer protection practices, digital identification, and financial/digital literacy might contribute to mitigating those risks (Sahay et al., 2020).

2.2.4 The impact of financial development

Extensive literature, dating at least as far back as Schumpeter (1911), highlights the positive influence of the development of a country's financial sector on the level and the rate of growth of its per capita income (Fagerberg and Srholec, 2008; Rajan and Zingales, 1998). Financial development is a multidimensional concept and can be defined as a combination of depth (size and liquidity of markets), access (the ability of individuals to access financial services), and efficiency (the ability of institutions to provide cost-effective and sustainable financial services, and the level of activity of capital markets) (Sahay et al., 2015a). The Schumpeterian perspective is that finance leads to growth because it fosters the so-called 'creative destruction' by efficiently allocating resources to proficient newcomers (Beck and de la Torre, 2007). Through broader access to external funds, talented newcomers are empowered and freed from the disadvantages that would otherwise arise from their lack of inherited wealth and absence of connections to the network of well-off incumbents (Rajan and Zingales, 2003). Well-functioning financial markets that play critical roles in reducing financing costs, allocating scarce resources, evaluating innovative projects, managing risk, and monitoring managers are essential to promoting innovation effectively (Hsu et al., 2014).

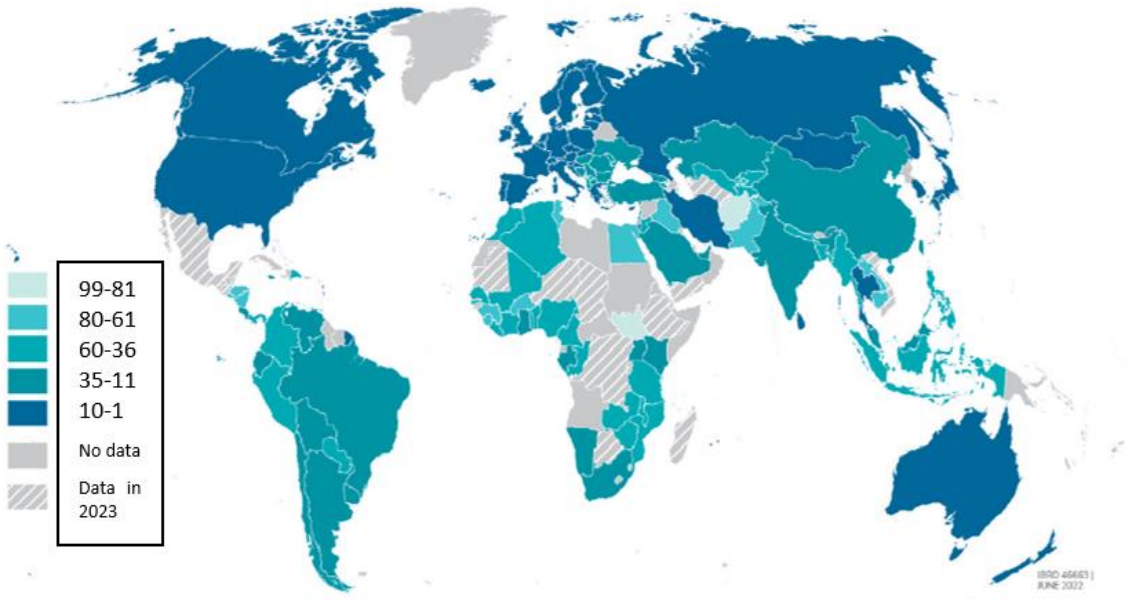
Broad access to financial services is related to the economic and social development agenda because extensive literature has shown the importance of a well-developed financial system for economic development and poverty alleviation. Access to financial services is perceived as a public good that is essential to enable participation in the benefits of a modern, market-based economy in an analogous way as the access to safe water, basic health services, and primary education (Peachey & Roe, 2006; Beck & de la Torre, 2007). Consistent with Schumpeter's view that the financial system can promote economic growth, some studies claim that higher levels of financial development are positively associated with faster rates of economic growth (Klapper, Laeven, and Rajan, 2006; Khan, 2012), physical capital accumulation (King & Levine,1993), larger reductions in poverty and income inequality (Beck, Demirgüç-Kunt, and Levine, 2007; Pazarbasioglu et al., 2020), economic efficiency improvements (Arner et al., 2020), and high rates of innovation (Rajan & Zingales, 1998; Hsu, Tian, and Xu, 2014).

However, some studies (e.g., Mader, 2018; Ozili, 2021) suggest that despite the success achieved in financial sector development in the global economy, those achievements have not necessarily transformed the lives of impoverished segments of the population positively, especially those who are outside the formal financial sector. The stark reality is that most of the world's disadvantaged population remains unbanked and/or lacks access to affordable financial services.

According to Global Findex Database 2021, from 2011 to 2021, account ownership around the world (at a financial institution or through a mobile money provider) increased by 50 percent. Yet, 1.4 billion adults remain unbanked worldwide (Figure 3), most of whom live in emerging

economies and tend to be concentrated among poorer households (Demirgüç-Kunt et al., 2022). So, why are so many poor people still financially excluded, whereas financial inclusion seems to be improving globally? One possible explanation is the persistent deficient digital financial infrastructure, especially in underprivileged communities and rural areas. Although mobile phones and the internet have created new opportunities for providing financial services, globally, only 25 percent of unbanked adults have both a mobile phone and access to the Internet in some form (Demirgüç-Kunt et al., 2018), and 13 percent of banked adults in developing economies reported that their bank accounts are totally inactive (Demirgüç-Kunt et al., 2022). Another possible reason is that destitute people represent an immense market currently underexploited due to reluctant perceptions of their very limited purchasing power.

Figure 3. Global unbanked population



Source: adapted from Demirgüç-Kunt et al., 2022.

Since most unbanked adults live in developing countries, no wonder the vast majority of empirical studies on financial inclusion have focused on gauging the effectiveness of low-cost financial innovations for lower-income markets in emerging economies. One of the most relevant of those works was carried out by Bruhn and Love (2014), whose results show that expanding access to finance to low-income individuals can positively impact economic activity. Their findings indicate that the financial inclusion program conducted by Banco Azteca in Mexico led to a positive impact on economic development through the channel of keeping individuals employed and fostering the survival and creation of informal businesses. Allen et al. (2020) analyzed the case of Equity Bank in Kenya, suggesting that financial inclusion can be achieved and sustained through profitable branching and service strategies that also serve the needs of traditionally underserved regions and populations. The researchers concluded that financial inclusion can be achieved without sacrificing bank profitability. Agarwal et al. (2017) studied the Indian government's Pradhan Mantri Jan Dhan Yojana (PMJDY) scheme, launched in 2014, which is considered one of the world's most extensive financial inclusion programs in the world. The authors resorted to micro and regional data to evaluate household usage of banking services and lending patterns.

Nevertheless, financial exclusion is a problem that also affects underprivileged households' wealth accumulation and economic well-being in advanced economies. Even those households and small businesses in developed countries that happen to hold a bank account, many of them only have access to a limited menu of cost-effective products from financial institutions to address their financial needs (Patwardhan, Singleton, and Schmitz, 2018). The Federal Deposit

Insurance Corporation (FDIC, 2017) reports that at least 25% of households in the United States (U.S.) are still unbanked or underbanked. Celerier & Matray (2019) highlight that 30% of the low-income population in the U.S. does not participate in the financial mainstream and, at the same time, possesses very little wealth. By using a natural experiment, the authors provide evidence that holding a bank account has a positive effect on wealth accumulation and that this effect occurs through better access to saving devices and loans. In a recent study, Citi Group (2020) concluded that, over the recent past, the focus in developed economies has been more on financial innovation and making banking simpler rather than financial inclusion. This might explain why, according to Florant et al. (2020), in the U.S., 30 million households and nearly half of black households are still unbanked or underbanked. In other words, despite the existing opportunities, there is still a great deal of financial precarity in developed countries.

2.2.5 Financial inclusion

A great number of studies on financial inclusion literature have emerged in academia (Khan, 2012; Joia & dos Santos, 2018), practice (McKinsey Global Institute, 2016; Demirgüç-Kunt et al., 2018; Citi Group, 2020), and policy (World Bank, 2017, 2018; UNSGSA, 2018) over the last few years. Those studies can be categorized into two main strands of research in the field of financial inclusion. The first school of thought reflects various financial inclusion definitions from many studies, integrating several different dimensions, such as access, availability, usage, or barrier, into a measure. It also entails the efforts made to develop a comprehensive index of financial inclusion that could take various dimensions into account (Sarma, 2008; Sahay et al.,

2015a; Liu & Walheer, 2022). Based on the constructed index, another strand of empirical studies focuses on either analyzing the factors causing the level of financial inclusion at country levels (Sarma, 2012) or investigating the impact of financial inclusion on other macroeconomic variables (Bruhn & Love, 2014), income inequality and economic growth (Sahay et al., 2015b), and even household levels (Zhang & Posso, 2017; Van et al., 2021).

However, most previous studies on financial inclusion have focused on traditional financial penetration, overlooking digital financial inclusion and lacking a more comprehensive assessment of the issue. The most recent papers that attempt to identify drivers of digital financial inclusion largely zero in on a specific country and/or firm (e.g., Zhang, Zhang, and He, 2018; Banna, Hassan, and Rashid, 2021) and do not capture the macroeconomic implications of digital financial inclusion. Thus, regarding the financial inclusion literature, there is still a shortage of understanding of financial inclusion conceptualization, its nature, and its implications in the digital era.

Although there has been no conclusive definition of financial inclusion in the literature (Van et al., 2021), one widely utilized interpretation is the one put forward by the Global Partnership for Financial Inclusion (GPFI) and World Bank (2021: 4), which says that “financial inclusion means that individuals and businesses have access to useful and affordable financial products and services that meet their needs – transactions, payments, savings, credit, and insurance – delivered in a responsible and sustainable way.” Financial inclusion is considered a problem not

just for low-income consumers but a grim reality that affects all countries and touches many people at different levels.

Nevertheless, other researchers concentrate on the impoverished populations and nonbanking organizations' needs. They focus on lower-income segments of the population that are often considered unbankable because of infrequent and small transactions and a lack of formal documentation, and also on MSMEs that constitute too high a risk for traditional financial institutions, given the lack of formal registration, proper financial information, and assets that can be used as collateral (Beck, 2020).

Even though the terms "unbanked" and "financially excluded" have been interchangeably used in the financial inclusion literature, we should bear in mind that providing bank accounts is just the first step toward bringing people into the formal mainstream. To the point that many of the so-called "banked" people are, in fact, not fully included in the financial system. Hence, it is vital to ensure that capital actually flows into their bank accounts, generating real financial inclusion, with people using their accounts to perform a variety of financial operations, such as making electronic payments, transferring money, taking loans, buying insurance, and saving part of their income, just to name a few.

Financial exclusion can also be conceived of as a type of inclusion (connected to the financial system) but under unfavorable terms. Zheng (2009) calls this kind of exclusion "unfavorable inclusion", where underprivileged communities' opinions are ignored, and their participation is

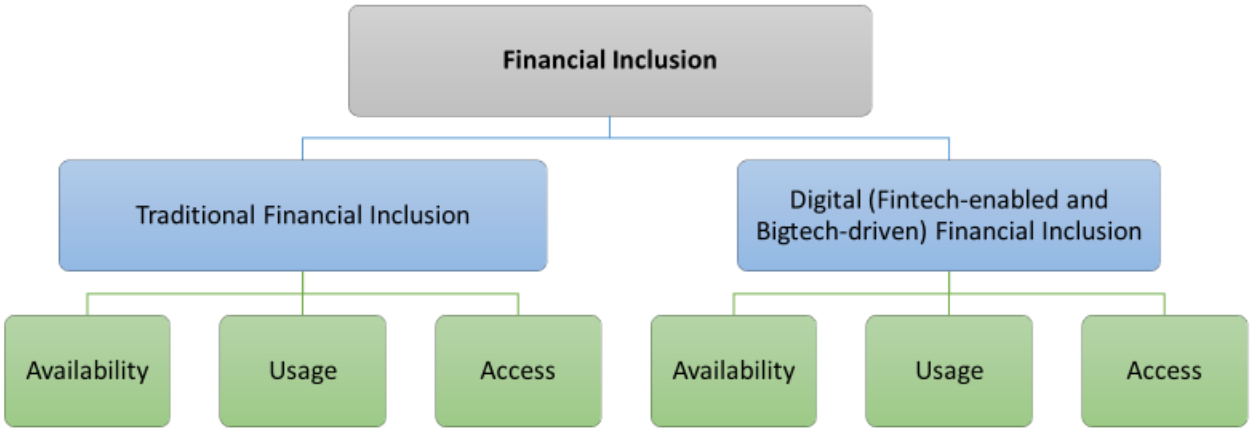
denied regarding financial products and services. In that sense, Joia & dos Santos (2018) argue that top-down financial inclusion initiatives that do not give voice to the local actors lead to a lack of articulation between the financial inclusion management and the interests of the local population.

Many scholars have put forward a composite index approach to quantify financial inclusion, considering the multidimensional aspect of financial inclusion. Sarma (2008, 2012, 2015) examines financial inclusion as a process of three main dimensions – the ease of availability, access, and usage of the formal financial system. Although the most common approaches to financial inclusion focus on the access and use of financial services, other dimensions, such as quality and efficacy, have started to be included in the concept, going more deeply into the nature and characteristics of access and use (García, 2016).

Following Sarma (2008, 2012, 2015), Liu and Walheer (2022) define financial inclusion from three main dimensions—availability, access, and usage, making use of both demand and supply-side data and recognizing that financial technology and digital finance are playing an increasing role in boosting financial inclusion. In their index, availability refers to the supply of financial services, the ownership of accounts assesses access, and the users of financial services determine usage. Sahay et al. (2020) consider digital inclusion and divide financial inclusion into digital and traditional components, drawing our attention to fintech-driven financial inclusion. By adding indicators specifically related to digital financial services, the researchers expand the scope of financial inclusion measurement in the existing literature.

Nevertheless, even though increasing attention has been focused on proposing reliable indicators to quantify financial inclusion, there is a lack in the literature of more comprehensive approaches that take into consideration the role played by disruptive financial advancements in providing financial services to destitute groups. Therefore, drawing on Liu and Walheer's (2022) approach, we present a model that identifies the dimensions of financial inclusion and examines both the supply and demand sides, and both digital and traditional components of financial inclusion, contrasting with previous studies that rarely consider fintech or bigtech (Figure 4).

Figure 4. Financial inclusion and its dimensions



Source: adapted from Sahay et al., 2020; Liu & Walheer, 2022.

Overall, there is no clear evidence about which side of the trade-off relative to financial innovation contrasts more (Beck et al., 2016). Due to previous data limitations, most studies in the existing literature provide text descriptions of fintech's potential opportunities and threats in

the banking industry (Lee et al., 2021), overlooking how fintech developments affect risks and fragility in the financial system. Additionally, little research has examined the role of fintech in promoting financial inclusion and financial stability. Existing studies have focused on the relationship between financial inclusion and financial stability, as well as the link between fintech innovation and stability, but have not thoroughly investigated their interrelationship (see Sant'Anna and Figueiredo (2024), for a comprehensive review). The analysis of the interrelationship between fintech innovation, financial inclusion, and the stability of the financial system can demonstrate whether financial inclusion is a key channel through which fintech innovation ensures (or threatens) financial stability. Therefore, we propose the following hypothesis:

Hypothesis 1: *Financial inclusion partially mediates the relationship between fintech innovation and financial stability.*

2.2.6 The individuals' financial capability gap

According to the capability approach developed by the winner of the Nobel Prize for Economics, Amartya Sen (1999), a capability is the combination of achievable opportunities that people have reason to pursue because they are valuable, while functionings are the real achievements that they reach. The capability approach stresses the importance of people's freedom to choose the type of life they have reason to value among several options and considers choice as being intrinsically important for well-being (Storchi & Johnson, 2016). Thus, poverty is not just

insufficient income but rather the absence of a wide range of capabilities, including security and the ability to participate in economic and political systems.

In that sense, financial capability refers to the freedom to participate and contribute among the economically and socially excluded people by creating equal opportunities for achieving financial well-being (khan, 2012). It combines both the opportunity to financially act with one's intrinsic ability to financially act (Johnson & Sherraden, 2007), which results in financial management behavior and financial well-being, and, as such, relies heavily on Sen's foundational theory of capabilities (Birkenmaier, Rothwell, and Agar, 2022). That is, financial capability seeks to enable people to make responsible financial decisions, understand how to manage credit and debt, and identify products and services that are appropriate in order to improve their well-being.

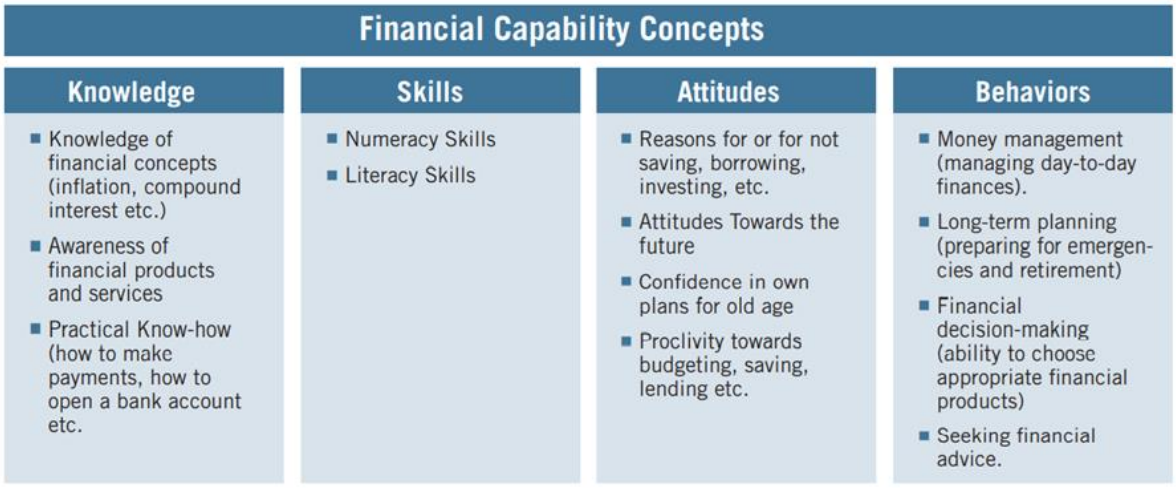
The literature on financial inclusion often employs the terms – financial literacy, financial education, and financial capabilities, sometimes interchangeably, whose overlap can confuse. Financial literacy is associated with possessing the ability to process economic information and make informed decisions about financial planning, wealth accumulation, debt, and pensions (Lusardi and Mitchell, 2014). In contrast, financial education is the process of building knowledge, skills, and attitudes to become financially literate (Cohen and Nelson, 2011). Individuals' financial capabilities – hereafter, financial capabilities – are the ability and opportunity to use the knowledge and skills implied in financial literacy and perform desirable financial behaviors to achieve financial well-being (Xiao and O'Neill, 2016). Therefore, they

encompass the knowledge, attitudes, skills, and behaviors of individuals regarding managing their financial resources and understanding, selecting, and making use of financial services that fit their needs (World Bank, 2013a) (Figure 5). Financial capability is a broader concept that links individual functioning to the entities of the financial system and should be explored and evaluated as a set of potential strategies that are continuously constructed through social relationships and within a particular cultural setting (Storchi & Johnson, 2016).

Beck and de la Torre (2007) champion that the lack of financial capability leads to lower demand for services than predicted by the economic capacity to pay as people might not know of the existence or affordability of specific payments or saving services, partly due to a generally low level of education. Thus, improving low-income households' financial capabilities can be greatly beneficial to their financial well-being (Cull, Demirguc-Kunt, and Morduch, 2009).

The Standard & Poor's Ratings Services estimates that only 33% of adults globally (and only 38% of account-owning adults) are financially literate, 57% of account owners in advanced economies, and 30% in emerging economies. That is, around 3.5 billion adults globally, most in developing and emerging economies, do not understand basic financial concepts (Klapper et al., 2015). The Global Findex Database 2021 also indicates that, in developing economies, 64 % of unbanked adults cannot use an account at a financial institution without help (Demirgüç-Kunt et al., 2022).

Figure 5. Dimensions of financial capabilities



Source: adapted from World Bank, 2013a.

Those studies draw our attention to the fact that while access to finance is expanding, financial capabilities are not improving at a similar pace. Governments and multilateral development agencies are pushing to increase financial inclusion by fostering access to bank accounts and other financial services. However, these opportunities can lead to serious financial consequences without the necessary financial capability-building initiatives. The lack of financial capabilities can prevent users from benefiting from account ownership because they do not understand how to use financial services in a way that optimizes benefits and avoids consumer protection risks such as high and hidden fees, over-indebtedness, aggressive marketing, data or identity theft, mobile app fraud, and discrimination. Although many of these risks are not new, they can be amplified given the reach and convenience of new technologies (Demirgüç-Kunt et al., 2022).

This situation is even worse for disadvantaged groups (e.g., women, impoverished people, and first-time users of financial services) who suffer from low financial capability, although they are frequently the target of government programs to expand financial inclusion (Klapper, Lusardi, and van Oudheusden, 2015). According to Deb and Kubzansky (2012), this lack of synchronicity has created a dangerous "financial capability gap"—an abysm that exists between those who have been given the skills and knowledge to responsibly engage with a formal financial system that is entirely new to them and those who have not.

Nevertheless, some authors (e.g., Almeida, 2021; Willis, 2021) present a different perspective regarding financial capabilities. They argue that customers do not need more financial capability-building programs since they have an accurate idea of their potential and what they need to thrive. Those authors think that financially unserved people need financial tools to help them retain and manage the capital they generate. Yunus (2007) asserts that low-income people are in such an unbearable situation not because they are untrained or illiterate but because they have no control over capital since financial institutions do not help them widen their economic base. Likewise, Collins et al. (2009) claim that underserved people are active, savvy, and skillful financial managers who seek better tools. They conclude that not having enough money is terrible enough, but not having the financial tools to manage whatever money one has is even worse.

Almeida (2021) claims that digital financial services providers are the ones in need of education—an education on what their consumers truly need, and how to make their products

more inclusive. Willis (2021) argues that financial education is typically used to refer to what might more accurately be called personal money management education, which cannot produce financial well-being in the current marketplace. She claims that because of the opportunity costs, alternative interventions (e.g., improving consumer protection standards and aligning incentives) are more likely to provoke satisfactory financial outcomes. Miller et al.'s (2014) meta-analysis of 188 financial education programs found that, on average, those programs have not had positive impacts on financial knowledge or behavior, and even where they worked, improvement was minimal, and the uptake was not considerable. Their results suggest that financial literacy and capability interventions can have a positive impact in some areas (e.g., increasing savings) but not in others (e.g., reducing loan defaults).

The COVID-19 global pandemic and its associated record-high unemployment rate and economic uncertainty have provided further impetus for research into financial capability (Birkenmaier, Rothwell, and Agar, 2022). Nonetheless, to date, there has been little research on understanding what financial capability means for low-income people or exploring the potential relationship between financial capability and financial inclusion and whether this actually leads to well-being improvements for marginalized segments of society (Storchi & Johnson, 2016).

To date, the evidence obtained regarding the role played by financial capabilities is not conclusive, which suggests that the links between financial capabilities, fintech innovation, and financial inclusion require further investigation. Since financial skills, knowledge, and understanding, as well as awareness of rights, responsibilities, and grievance channels, might

potentiate the responsible and sustainable use of fintech by financially underserved people, it is possible that fintech will have a larger impact on financial inclusion when financial capabilities are present. That is, we posit that the relationship between fintech innovation and financial inclusion might be moderated by individuals' financial capabilities. Thus, we hypothesize that:

Hypothesis 2: *The relationship between fintech innovation and financial inclusion is moderated by individuals' financial capabilities. It is positive (negative) for countries with high (low) levels of individuals` financial capabilities*.

2.2.7 The financial inclusion dilemma

Surprisingly, the findings and arguments supporting financial inclusion are not unopposed. One recent strand of literature on financial inclusion (e.g., Bateman, 2012; Duvendack and Mader, 2020; Ozili, 2020a) contests the claims that financial inclusion improves development outcomes or helps reduce poverty. It challenges the reasoning that financial inclusion is a core pro-poor private-sector-led development intervention. Instead, it shows financial inclusion as a contested and contestable enterprise. The argument is that there is insufficient evidence for financial inclusion being development-promoting, poverty-alleviating, and profitable enough, to justify the attention and resources mobilized (Mader, 2018).

Other studies (e.g., Deb and Kubzansky, 2012; Diniz et al., 2012) highlight the drawbacks of financial inclusion initiatives. They argue that while financial inclusion through ICT enterprise

does contribute positively to local socio-economic development, it also presents clear negative signs such as over-indebtedness among the low-income population, reproduction of social exclusion practices, and reinforcement of power asymmetries. The studies assert that access to financial resources is a fundamental way to promote local development for the low-income population, but such access should also be accompanied by other inclusive mechanisms to be effective. In contributing to this debate, Ozili (2020b) criticizes some aspects of the global financial inclusion agenda by claiming that too much financial inclusion may become undesirable. He points out that an exaggeration regarding financial inclusion might lead to an outcome like the dot.com bubble of the 2000s, which was replete with corporate governance scandals in many technology firms, and the 2008 global financial crisis, where financial innovations (e.g., credit derivatives) were pushed too far by investment banks that wanted to make much profit at the expense of subprime borrowers and unsophisticated investors.

The consequences of the Great Recession of 2008 on the global economy were unprecedented, which awakened the interest of policymakers worldwide, prompting various initiatives to bring stability to the financial system and foster financial inclusion (Danisman and Tarazi, 2020). Since that crisis, the theme of financial stability has attracted the attention of policymakers, academics, and practitioners. A stable financial system can efficiently allocate resources, assess and manage financial risks, maintain employment levels close to the economy's natural rate, and eliminate relative price movements of tangible or financial assets that will affect monetary stability or employment levels (World Bank, 2022a).

The literature has typically considered financial inclusion and the strength of the financial system separately, and the link between them is largely ignored. Few studies have investigated their interconnectedness or whether synergies or trade-offs exist between them (Danisman and Tarazi, 2020). Therefore, the literature on the nexus between financial inclusion and financial stability is relatively thin and provides contradicting views on how these two outcomes are related (Čihák et al., 2016; García, 2016; Khan, 2012).

On the one hand, some authors claim that by providing greater access to and better uses of banking services to a vast section of society, including the disadvantaged groups, financial inclusion efforts ensure the efficiency of resources and financial intermediation, which, in turn, boost financial stability, depending on the level of improved financial infrastructure and skilled supervision the country has managed to implement (Siddik and Kabiraj, 2018). By utilizing dynamic panel data with a sample of 4,168 banks in 28 countries for the 2010–2017 period, Danisman and Tarazi (2020) found a positive relationship between financial inclusion and financial stability in the context of European Union (EU) countries. Likewise, using an international sample of 2,635 banks across 86 countries, Ahamed and Mallick (2019) provide comprehensive empirical evidence that greater financial inclusion is positively associated with individual bank stability.

According to that perspective, financial inclusion can foster stability in the banking system through the diversification of risks by lending to more individuals and businesses (Morgan and Pontines, 2014). Broader access to deposits that lead to a more diversified base of deposits can

significantly improve the resilience of the overall financial system and, thus, financial stability (García, 2016; Han and Melecky, 2013). Through a data panel analysis of 68 countries between 2006 and 2015, De Moraes et al. (2020) suggest that bank interest rate spread is lower in countries with greater financial access, leading to a reduction in the cost of credit, which ultimately contributes to the efficiency of the financial system. Danisman and Tarazi (2020) argue that when banks extend credit to MSMEs or individual borrowers, they derive diversification benefits and experience a reduction in the volatility of their loan portfolios through a reduction in the relative size of a single borrower and its interconnectedness risk. An increase in small savers diminishes banks' reliance on more volatile wholesale financing. Therefore, the industry's stability improves with a decrease in pro-cyclicality risk.

On the other hand, other authors argue that considerable extension of financial systems may threaten banking sector vulnerability and create multiple liquidity exposure risks. They claim that due to asymmetric information, expanding bank credit to impoverished people can raise subprime lending and credit default (García, 2016), which often brings financial instability through potential risks (Barik and Pradhan, 2021). Čihák et al. (2016) argue that, on average, financial inclusion and financial stability are negatively correlated and thus linked more through trade-offs than synergies. Their study results suggest that greater financial inclusion, particularly associated with extensive borrowing by individuals, may also increase the risk of extreme events, unexpected losses to the financial system, and, ultimately, more frequent banking crises.

2.2.8 Regulatory and supervisory frameworks

According to Danisman and Tarazi (2020), financial instability risks increase when access to credit is expanded without proper supervision and regulation. García (2016) also argues that adequate regulation and supervision of new financial inclusion instruments and institutions and effective financial consumer protection practices are vital to ensuring that greater access and use of finance do not endanger financial stability. Examples of good financial consumer protection practices include strong product transparency, robust redress mechanisms, appropriate incentive structures for service providers, responsible fee pricing, and banning predatory or deceptive sale techniques (GPFI and World Bank, 2021).

Sahay et al. (2015b) suggest that countries with strong supervision could see some financial stability gains from higher inclusion. The authors point to large differences in the effectiveness of supervision across countries, signaling the potential risks to financial stability from an unchecked broadening of access to credit. Thus, the impact of financial penetration on financial stability might be greater when the country has strict financial regulation and supervision. Financial institutions may also limit access to financial services for low-income groups in times of regulatory tightening to boost profits and cut off risky customer segments (Čihák et al., 2016).

On the other hand, excessive regulation and supervision may lead to the imposition of unnecessary barriers to development, innovation, and competition (Gispert et al., 2022). The entry of new businesses and the introduction of new, technology-enabled business models

depend on regulators' approach (Feyen et al., 2023). Put differently, an inappropriate calibration of the regulatory and supervisory frameworks for basic financial services according to their contribution to risks for the entire financial system can also become a cause for exclusion.

Moreover, overregulation imposes excessive compliance costs and regulatory burdens, locking down the competition. This is particularly critical when incumbents own the financial infrastructure. Thus, regulators must ensure that financial infrastructures have fair and transparent access policies (Feyen et al., 2023). The intensity of the supervision must be "proportionate" to the risks involved—the intention of supervision cannot be to raise the cost of capital to the point of nonviability of lenders. It is even more complicated when financial inclusion is provided by many institutions outside the regular banking system or the unregulated financial sector (Sahay et al., 2015b).

Put differently, an inappropriate calibration of the regulatory and supervisory frameworks for basic financial services according to their contribution to risks for the entire financial system can also become a cause for exclusion. This will likely require regulators to also resort to technology – regulatory technology or "regtech" and supervisory technology or "suptech," to respond to fintech development. Regtech includes automation and data-driven analysis of internal control systems and internal and external reporting to enhance regulatory and compliance processes. Likewise, "suptech" is using ICT to support the supervision of finance products and services (Arner et al., 2020; Sahay et al., 2020).

The relationship between financial inclusion and financial stability, and the channels through which financial inclusion might influence financial stability are still unclear in the literature (García, 2016; Ozili, 2020; Barik and Pradhan, 2021). The potential effects of financial penetration on the stability of the financial system are relevant, and closer scrutiny is needed to assess the economic impacts, their nature (positive or negative), and the order of magnitude.

By employing selected cross-country data and relying mostly on the IMF's Financial Access Survey, Sahay et al. (2015b) suggest that countries with strong supervision could see some financial stability gains from higher inclusion. The authors point to large differences in the effectiveness of supervision across countries, signaling the potential risks to financial stability from an unchecked broadening of access to credit. Thus, the impact of financial penetration on financial stability might be greater when the country has strict financial regulation and supervision. Financial institutions may also limit access to financial services for low-income groups in times of regulatory tightening in an attempt to boost profits and cut off risky customer segments (Čihák, Mare, and Melecky, 2016), which would lead to important consequences for the stability of the financial system. That is why it is crucial to investigate whether advancing financial inclusion endangers financial stability and how the country's regulatory and supervisory frameworks affect the trade-off between financial inclusion and stability.

Thus, since risks arise from uncontrolled and rapid credit growth associated with financial inclusion initiatives and from unregulated and unsupervised elements of the financial system,

maybe the correlation between financial inclusion and financial stability is moderated by a country's regulatory and supervisory frameworks. We, therefore, hypothesize that:

Hypothesis 3: *The relationship between financial inclusion and financial stability is moderated by regulatory and supervisory frameworks. It is positive (negative) for countries with more (less) robust regulatory and supervisory frameworks.*

2.2.9 First and second stage moderated mediation

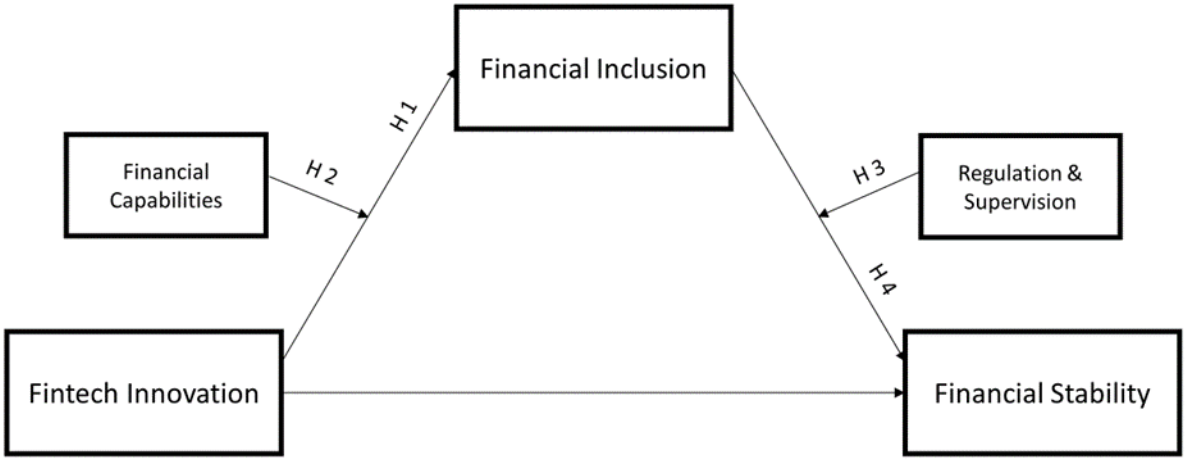
Furthermore, to move a step further in the investigation of the dilemma of whether fintech innovation is beneficial or detrimental to financial inclusion and the stability of the financial system, we propose that fintech innovation affects financial stability directly and indirectly through financial inclusion. Still, we emphasize the critical nature of our two moderators (financial capabilities and regulation and supervision) in fully understanding this mediation. Thus, we hypothesize that:

Hypothesis 4: *The mediating role of financial inclusion in the relationship between fintech innovation and financial stability is moderated by financial capabilities and regulation and supervision.*

Hence, as Figure 6 illustrates, we ultimately propose a first and second stage moderated mediation model that aims to shed light on the potential of fintech innovation to integrate low-income populations into the formal financial system and examine the impact of such innovation

on financial stability. Based on the previously reviewed studies, we expect that fintech has a positive direct and a positive indirect effect (mediated by financial inclusion) on financial stability. We also predict that financial capabilities positively moderate the relationship between fintech innovation and financial inclusion, whereas regulation and supervision positively moderate the effect of financial inclusion on financial stability. Table 1 summarizes the four hypotheses as well as our expectations regarding the estimations' results.

Figure 6. The study's conceptual framework and hypotheses



Source: the author.

Table 1
Hypothesis summary

Hypothesis	Description	Expectations
H1 - Mediation	Financial inclusion partially mediates the relationship between fintech innovation and financial stability.	The relationship between fintech transactions and financial stability is partially mediated by financial inclusion, with the direct, indirect, and total effects being positive and both statistically and economically significant.
H2 – First Moderation	The relationship between fintech innovation and financial inclusion is moderated by individuals' financial capabilities. It is positive (negative) for countries with high (low) levels of individuals` financial capabilities.	Financial capabilities positively and significantly affect the effect of fintech innovation on financial inclusion. Higher levels of fintech transactions are associated with more financial inclusion when the country had higher levels of financial capabilities.
H3 – Second Moderation	The relationship between financial inclusion and financial stability is moderated by regulatory and supervisory frameworks. It is positive (negative) for countries with more (less) robust regulatory and supervisory frameworks.	Regulation and supervision positively and significantly affect the effect of financial inclusion on financial stability. Countries that seek financial inclusion with strong regulatory and supervisory frameworks achieve higher levels of financial stability.
H4 – First and Second Stage Moderated Mediation	The mediating role of financial inclusion in the relationship between fintech innovation and financial stability is moderated by financial capabilities and regulation and supervision.	Both moderations and the partial mediation are significant and consistent, confirming the first and second stage moderated mediation.

3 – METHODS

3.1 – Sample and data construction

To construct our sample, we collected data from several datasets at the country level. We then selected the sampled countries based on the following criteria. From the perspective of geographical distribution, these countries are from various regions: Asia, Europe, Africa, Oceania, North America, and South America. This comprehensive geographical coverage ensures the representation of a diverse range of countries and enhances the external validation of the findings. The sampled countries cover developed countries (e.g., Finland and Japan) and emerging and developing economies (e.g., Brazil and China). This sampling ensures a certain degree of comprehensiveness in representing economies at various stages of development, providing robust representation. Finally, we selected balanced panel data from 82 countries from 2013 to 2021 due to data availability and completeness constraints. Table 2 shows the specific countries sampled for this study.

Data scarcity is one of the main challenges we encountered in addressing our hypotheses. That is why, to overcome this hurdle, we resorted to various databases. The first one was the Global Financial Development Database, produced by the World Bank, which is deemed one of the most extensive cross-country datasets in this area. It contains cross-country time-series data from many countries on a significant number of variables linked to financial stability and financial inclusion, as well as some variables of economic development (Siddik and Kabiraj, 2018). The

Global Financial Development Database was critical in helping us assess the stability of the financial system.

Table 2

The sampled countries for this study

Albania	Egypt*	Lebanon*	Slovak Republic
Algeria*	Estonia	Lithuania	Slovenia
Argentina	Finland	Malaysia	South Africa
Australia*	France	Malta	South Korea
Austria	Georgia	Mexico	Spain
Bangladesh*	Germany	Moldova	Sweden
Belarus	Ghana*	Netherlands	Switzerland*
Belgium	Greece	New Zealand	Tanzania*
Brazil	Hong Kong	Nigeria*	Thailand
Bulgaria	Hungary	North Macedonia	Tunisia*
Cambodia	India	Norway	Turkey
Canada	Indonesia	Panama	Uganda*
Chile	Ireland	Paraguay	Ukraine*
China	Israel*	Peru	United Arab Emirates*
Colombia	Italy	Philippines	United Kingdom
Costa Rica	Japan*	Poland	United States*
Croatia	Jordan	Portugal	Uruguay
Cyprus	Kazakhstan*	Romania	Vietnam*
Czech Republic	Kenya*	Russian Federation	Zambia*
Denmark*	Kuwait*	Saudi Arabia	
Ecuador*	Latvia	Singapore*	

* Data on individuals` financial capabilities were not available

As previously discussed, gauging fintech activity can be very challenging, given the diversity and constantly evolving landscape of fintech providers, the small size of many platforms, and the fact that many providers still lie outside prudential regulatory reporting requirements. To respond to this challenge, we turned to two databases – the Global Alternative Finance Data Depository

hosted by the Cambridge Centre for Alternative Finance (CCAF) and the Global Financial Inclusion Database (Findex). The primary fintech data were obtained from the CCAF database[4], which divides fintech developments into two main categories: (i) digital lending and (ii) digital capital raising (Cevik, 2023). We used this novel dataset to trace fintech development (excluding cryptocurrencies) and empirically assess its impact on financial stability.

Regarding our mediator – financial inclusion, the International Monetary Fund's Financial Access Survey (FAS) provided us with aggregate data on the supply of and access to financial services. It is a relevant source of global supply-side data on financial inclusion, encompassing internationally comparable basic indicators of financial access and usage. The World Bank's Financial Inclusion dataset – the Global Findex, also provided us with data on the use of financial services in several economies. It is a demand-side individual-level financial inclusion database that measures how individuals save, borrow, make payments, and manage risk. Since our analyses took place at the country level, we used data from these databases to measure the access and usage dimensions of the financial inclusion variable.

Concerning our two moderators – financial capabilities and regulation and supervision, we drew on two other databases. The OECD/INFE International Survey of Adult Financial Literacy Competencies provides information about financial literacy beyond knowledge and skills, covering aspects of economic behavior and financial attitudes (World Bank Group, 2013b). This survey provided insights into our sampled countries' financial capabilities (Pesqué-Cela et al.,

[4] The CCAF dataset excludes mobile money and internet banking, which are also operated by traditional financial Institutions (Cevik, 2023). However, our other proxy for fintech innovation – fintech adoption, the use of mobile phones to pay bills (Demir et al., 2022) is intended to capture both mobile money and internet banking.

2020). The IMF-World Bank Financial Sector Assessment Program (FSAP) equipped us with data derived from in-depth assessments of financial sectors around the globe. It is an essential source of comparable information on the quality of regulatory and supervisory frameworks. FSAP allowed us to gauge a country's regulatory and supervisory foundation, utilizing the weighted average capital adequacy ratio of financial institutions in a country to measure its financial regulation (Hua et al., 2023).

Data about the control variables came from the World Development Indicators database, the primary World Bank collection of development indicators, compiled from officially recognized international sources. It presents current and accurate global development data and includes national, regional, and global estimates.

Finally, regarding the instrumental variable—broadband cost (the global mobile data pricing)—we turned to Cable.co.uk database, which undertakes annual tracking studies covering the average broadband speed and the cost of broadband packages worldwide. Cable.co.uk's global telecoms research is regularly featured in leading international publications, including the BBC (BBC, 2019) and the World Economic Forum (World Economic Forum, 2019).

3.2 – Variables

3.2.1 Dependent variable

Common empirical proxies for financial stability in the literature are bank nonperforming loans/loans, risk premiums (e.g., bank Z-scores), and data on the presence and absence of banking crises (Čihák and Sahay, 2020; García, 2016). The popularity of the Z-score stems from the fact that it has a clear (negative) relationship to the probability of a financial institution's insolvency. In other words, the probability that its assets' value becomes lower than its debt's value. A higher Z-score implies a lower probability of insolvency (World Bank, 2022a).

According to a recent International Monetary Fund study (Elekdag et al., 2024), the Z-score is an important measure in the assessment of the stability of financial institutions. It has been widely used in empirical banking studies to gauge a bank's risk of failure or distress because it encompasses both profitability and capitalization, as well as the volatility of earnings. Higher Z-score values indicate more solid stability, also known as lower bankruptcy risk. Thus, following many contemporary papers, such as Cevik (2023) and Liu et al. (2024), this research study used the natural logarithm of the national level of Z-score to measure financial stability. We used its natural logarithm because the bias and heteroscedasticity of Z-score, a measure of bank risk, may interfere with the empirical results (Liu et al., 2024). Therefore, to ensure the reliability of research conclusions, this study took the natural logarithm of Z-score to estimate the equations.

Moreover, to expand our analysis, we followed Elnahass et al. (2021). In our empirical model, we used two other indicators of bank risk that can also represent the financial stability of the banking sector: liquidity risk and asset risk. Liquidity risk is proxied by liquid assets to deposits and short-term funding (LA/DSF) (%). Put differently, it is the ratio of the value of liquid assets (easily converted to cash) to short-term funding plus total deposits. It represents a short-term risk

to the stability of the financial sector. Higher values of liquidity risk imply lower risk. Asset risk is estimated by bank return on assets (ROA - commercial banks' pre-tax income to yearly averaged total assets) divided by the standard deviation of ROA (ROA/SDROA). Higher values of asset risk imply lower risk to the financial system.

3.2.2 Independent variables

We used fintech transactions as our primary independent variable to capture countries' degrees of fintech innovation adoption. Our key explanatory variable of interest is the volume of fintech transactions (excluding cryptocurrencies), collected from the Global Alternative Finance Data Depository hosted by the Cambridge Center for Alternative Finance (CCAF, 2021). This variable encompasses digital lending and digital capital-raising. Digital lending refers to the volume of lending instruments through digital platforms, whereas digital capital raising is the volume of capital-raising instruments through digital platforms (Cevik, 2023; Elekdag et al., 2024).

Moreover, in our robustness checks, we also considered an alternative measure of the fintech innovation variable utilized by Demir et al. (2022) – fintech adoption, the use of mobile phones to pay bills. Although this variable is not comprehensive of all fintech adoption, we believe it provides a reasonable proxy for capturing its spread since an increasing share of fintech providers (both newer startups and traditional incumbents) establish a customer-provider relationship and deliver their services via mobile applications. This is particularly true given the increasing pervasiveness of smartphones and mobile internet coverage, including in lower- and middle-income economies (Fu and Mishra, 2020).

3.2.3 Mediator

Many studies in the finance literature have developed reliable indexes to assess the dimensions of financial inclusion. One of the most referred indexes is Sarma's financial inclusion index (Sarma, 2008; 2012; 2015), which summarizes information on three dimensions of an inclusive financial system – banking penetration, availability, and usage of banking services into a single number. Sarma's index uses a point in the n-dimensional Euclidean space to indicate a country's achievements in these three dimensions. Given two reference points (the worst and the best achievements), a country's level of financial inclusion is then measured by how far the country's achievement point is from these reference points in each dimension of financial inclusion (Sarma, 2015).

The dimension index d_i is computed by the formula below. A weight w_i such that $0 \leq w_i \leq 1$ is attached to the dimension i.

$$d_i = w_i \frac{A_i - m_i}{M_i - m_i}$$

$$IFI = ½[\frac{\sqrt{d_1^2 + d_2^2 + d_3^2}}{\sqrt{3}} + (1 - \frac{\sqrt{(1-d_1)^2 + (1-d_2)^2 + (1-d_3)^2}}{\sqrt{3}})]$$

where
Wi = weight attached to the dimension i, $0 \leq W_i \leq 1$
A_i = actual value of dimension i
m_i = lower bound on dimension i, fixed by some pre-specified rule.
M_i = upper bound on dimension i, fixed by some pre-specified rule.
IFI = Index of Financial Inclusion

The size of the ‘banked’ population, in other words, the proportion of people having a bank account, is a measure of the banking penetration of the system. However, data on the number of ‘banked’ people is not readily available. In the absence of such data, we used the number of deposit bank accounts per 1000 adult population as a proxy indicator of this dimension. Regarding the availability dimension, we utilized data on the number of bank branches and the number of ATMs per 100,000 adults to measure it. Finally, we considered two basic services of the banking system – credit and deposit, to measure the usage dimension. We used the data on the volume of credit to the private sector and deposits mobilized from the private sector as a proportion of the country’s GDP (Sarma, 2015).

3.2.4 Moderators

Following the dimensions suggested by the World Bank (2013a), we gauged financial capabilities through financial knowledge and skills, financial behavior, and financial attitudes, resorting to the OECD/INFE International Survey of Adult Financial Literacy Competencies. The financial knowledge and skills dimension provides a good overview of a person’s basic knowledge, general willingness to absorb financial information, and ability to apply knowledge to specific problems. The financial behavior dimension includes behaviors promoting financial well-being, such as saving and planning. Finally, the financial attitudes dimension measures respondents’ attitudes towards money and planning for the future. The overall financial capabilities score is obtained as the sum of the three dimensions scores (financial knowledge, financial behavior, and financial attitudes) at the respondent’s level. As for bank regulation and supervision, we turned to a proxy commonly found in the literature (e.g., Hua et al., 2023) –

bank regulatory capital to risk-weighted assets (RWA). The capital adequacy of deposit takers is the ratio of total regulatory capital to its assets held, weighted according to the risk of those assets.

3.2.5 Control variables

Furthermore, we include a comprehensive set of control variables potentially affecting financial inclusion and financial stability (Demir et al., 2022; Elekdag et al., 2024). These control factors include macroeconomic indicators such as GDP growth, inflation as measured by the annual growth rate of the GDP implicit deflator, unemployment as a percentage of the total labor force, and the natural logarithm of the total population. Table 3 summarizes the description of all variables, including their definitions, the dataset source, and other authors that have employed the same variables in previous studies, whereas Table 4 provides summary statistics for our sample, presenting the correlations between our variables of interest. The fact that the highest absolute correlation (0.44 between *fintech adoption* and *fintech transactions*) is the only one above 0.4 and between two proxies of the same variable (the independent variable fintech innovation) reduces our concerns with possible collinearity issues.

Table 3

Description of the variables

Variables	Definitions	Sources	References
Financial stability	It is also called Default Risk, which is measured by the Z-score. It captures the probability of default of a country's commercial banking system. The Z-score compares the buffer of a country's commercial banking system (capitalization and returns) with the volatility of those returns. The use of the natural logarithm of the Z-score mitigates the bias and heteroscedasticity of the Z-score, which may interfere with the empirical results. Higher values of Ln Z-Score imply lower risk.	Global Financial Development Database	Cevik, 2023; Elnahass et al., 2021; Liu et al., 2024.
Liquidity risk	Liquidity risk is proxied by liquid assets to deposits and short-term funding (LA/DSF) (%). The ratio of the value of liquid assets (easily converted to cash) to short-term funding plus total deposits. Liquid assets include cash and due from banks, trading securities at fair value through income, loans, advances to banks, reverse repos, and cash collaterals. Deposits and short-term funding include total customer deposits (current, savings, and term) and short-term borrowing (money market instruments, CDs, and other deposits). Higher values of LA/DSF imply lower risk.	Global Financial Development Database	Elnahass et al., 2021.
Asset risk	Asset risk is estimated by bank return on assets (ROA - commercial banks' pre-tax income to yearly averaged total assets) divided by the standard deviation of ROA (ROA/SDROA). Higher ROA/SDROA values imply lower risk.	Global Financial Development Database	Elnahass et al., 2021.
Fintech transactions	The volume of fintech transactions (excluding cryptocurrencies). Natural Log of total volume of digital lending and capital raising activities in US$.	Cambridge Centre for Alternative Finance (CCAF)	Cevik, 2023.
Fintech adoption	Mobile phone used to pay bills (% age 15+). The percentage of respondents who report personally making regular payments for water, electricity, or trash collection in the past year using a mobile phone.	Global Financial Inclusion Database (Findex)	Demir et al., 2022.
Financial inclusion	Sarma's financial inclusion index summarizes information on banking penetration, availability, and usage of banking services into a single number. The index comprises the number of deposit bank accounts per 1000 adult population, the number of bank branches and ATMs per 100,000 adults, and the volume of credit to the private sector and deposits mobilized from the private sector as a proportion of the country's GDP.	Global Financial Inclusion Database (Findex) and International Monetary Fund's Financial Access Survey (FAS)	Sarma 2008, 2012, 2015.

Table 3 – continued

Variables	Definitions	Sources	References
Financial capability	The Financial Capability Score is a constructed measure that sums up scores on questions measuring financial knowledge, behaviors, and attitudes. The overall scores range from 0 to 100. Higher scores reflect higher levels of financial literacy.	OECD/INFE International Survey of Adult Financial Literacy Competencies	World Bank, 2013a, 2013b.
Regulation and supervision	Regulatory Capital to Risk-Weighted Assets (RWA) - The capital adequacy of deposit takers. It is a ratio of total regulatory capital to its assets held, weighted according to the risk of those assets.	IMF-World Bank Financial Sector Assessment Program (FSAP)	Hua et al., 2023.
GDP growth	Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources.	World Bank - World Development Indicators	Cevik, 2023; Demir et al., 2022.
Inflation	Inflation, GDP deflator (annual %). Inflation, as measured by the annual growth rate of the GDP implicit deflator, shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency.	World Bank - World Development Indicators	Cevik, 2023; Demir et al., 2022.
Unemployment	Unemployment, total (% of the total labor force) (modelled ILO estimate). Unemployment refers to the share of the labor force without work but available for and seeking employment.	World Bank - World Development Indicators	Cevik, 2023; Demir et al., 2022.
Population	Total population	World Bank - World Development Indicators	Cevik, 2023; Demir et al., 2022.
Broadband cost	The average monthly cost of a broadband package in USD. All prices gathered were for fixed-line broadband packages, either ADSL or some form of fiber.	Cable.co.uk	World Economic Forum, 2019.

Table 4

Descriptive statistics and correlations

Variables	Mean	STD	1.	2.	3.	4.	5.	6.	7.	.8.	9.	10.	11.	12.	13.
1. Financial stability	2.66	0.56	1												
2. Liquidity risk	31.71	15.95	0.041	1											
			(0.291)												
3. Asset risk	3.73	2.67	0.388***	-0.051	1										
			(0.000)	(0.196)											
4. Fintech transactions	15.98	3.69	0.110***	0.214***	0.088**	1									
			(0.005)	(0.000)	(0.025)										
5. Fintech adoption	7.24	8.93	0.095**	0.223***	0.098**	0.440***	1								
			(0.015)	(0.000)	(0.012)	(0.000)									
6. Financial inclusion	0.28	0.15	-0.069*	-0.040	-0.204***	0.232***	0.167***	1							
			(0.078)	(0.305)	(0.000)	(0.000)	(0.000)								
7. Financial capability	60.95	5.86	0.069	0.254***	0.007	0.335***	0.306***	0.369***	1						
			(0.143)	(0.000)	(0.881)	(0.000)	(0.000)	(0.000)							
8. Reg. and sup.	17.61	3.60	-0.181***	0.360***	-0.086**	0.102***	0.258***	-0.052	0.061	1					
			(0.000)	(0.000)	(0.027)	(0.009)	(0.000)	(0.184)	(0.197)						
9. GDP growth	2.13	3.79	0.078**	-0.209***	0.245***	-0.119***	-0.280***	-0.179***	0.008	-0.016	1				
			(0.047)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.865)	(0.683)					
10. Inflation	3.80	7.02	-0.163***	0.040	0.051	-0.079**	-0.098**	-0.204***	-0.232***	-0.088*	-0.135***	1			
			(0.000)	(0.310)	(0.190)	(0.043)	(0.012)	(0.000)	(0.000)	(0.024)	(0.001)				
11. Unemployment	7.31	5.05	-0.068*	-0.093**	-0.265***	-0.181***	-0.160***	0.141***	-0.110**	-0.175***	-0.218***	0.032	1		
			(0.084)	(0.018)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)	(0.000)	(0.000)	(0.420)			
12. Population	16.75	1.56	0.061	-0.123***	0.113***	0.346***	-0.033	-0.169***	-0.077*	-0.336***	0.066*	0.130***	-0.154***	1	
			(0.121)	(0.002)	(0.004)	(0.000)	(0.397)	(0.000)	(0.099)	(0.000)	(0.094)	(0.001)	(0.000)		
13. Broadband cost	41.82	28.56	0.287***	0.061	0.160***	-0.028	0.177***	-0.162***	0.158**	0.025	0.015	-0.091*	-0.134**	-0.025	1
			(0.000)	(0.268)	(0.004)	(0.619)	(0.001)	(0.003)	(0.017)	(0.658)	(0.789)	(0.099)	(0.015)	(0.658)	

*Notes: Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.1*

3.3 – The statistical model

According to Hayes (2018), mediation analysis is used to quantify and examine the direct and indirect pathways through which an antecedent variable X transmits its effect on a consequent variable Y through one or more intermediary or mediator variables. Moderation analysis is used to examine how the effect of antecedent variable X on a consequent Y depends on a third variable or set of variables. Conditional process analysis is both of these in combination and focuses on the estimation and interpretation of the conditional nature (the moderation component) of the indirect and/or direct effects (the mediation component) of X on Y in a causal system.

Our model proposes a moderated mediation. Moderated mediation occurs when a moderator variable interacts with a mediator variable such that the value of the indirect effect changes depending on the value of the moderator variable (Hayes, 2018). This is known as a conditional indirect effect, i.e., the value of the indirect effect is conditional on the value of the moderator variable (Preacher, Rucker, and Hayes, 2007). Our empirical model (see Figure 6) has two different moderator variables: one that moderates the path between the independent variable (fintech innovation) and the mediator variable (financial inclusion) – individuals' financial capabilities, and one that moderates the path between the mediator variable (financial inclusion) and the dependent variable (financial stability) – regulatory and supervisory frameworks.

Our statistical model utilized a GMM balanced panel to test the four hypotheses. We chose random-effects models over fixed-effects models for three reasons. First, the result of the

Hausman (1978) test suggested the preferred model was random-effects ($p > 0.05$). Second, fixed-effects models reduce degrees of freedom and may generate biased estimates (Wooldridge, 2002). Third, since individuals' financial capabilities and regulation and supervision frameworks change quite slowly over short time-periods, using a fixed-effects model may severely constrain our analyses (Plümper and Troeger, 2007).

4. RESULTS

4.1 – Regression results of the fintech innovation-financial stability relationship

Initially, to determine the within-country financial stability and financial inclusion impacts of fintech innovation, taking into consideration the potential moderating role played by financial capabilities and regulatory and supervisory frameworks, we estimated the following model based on Preacher's et al. (2007) and Hayes's (2018) approach to testing moderated mediation in path analysis.

$$(I)\ financial\_inclusion_{i,t} = a_0 + a_1 fintech\_transactions_{i,t} + a_2 financial\_capabilities_{i,t} + a_3 fintech\_transactions_{i,t} * financial\_capabilities_{i,t} + \Gamma X_{it} + \varepsilon_{it}$$

$$(II)\ financial\_stability_{i,t} = b_0 + b_1 financial\_inclusion_{i,t} + b_2 fintech\_transactions_{i,t} + b_3 financial\_capabilities_{i,t} + b_4 fintech\_transactions_{i,t} * financial\_capabilities_{i,t} + b_5 regulation\_supervision_{i,t} + b_6 finacial\_inclusion_{i,t} * regulation\_supervision_{i,t} + \Gamma X_{it} + \varepsilon_{it}$$

$$(III)\ conditional\_indirect\_effect_{i,t} = (b_1 + b_6 regulation\_supervision_{i,t}) * (a_1 + a_3 financial\_capabilities_{i,t}) + \Gamma X_{it} + \varepsilon_{it}$$

where $financial\_stability_{i,t}$ refers to the stability of the financial system; $fintech\_transactions_{i,t}$ denotes the volume of fintech transactions; $financial\_inclusion_{i,t}$ relates to availability, access, and use of both traditional and digital financial services; f*inancial_capabilities* is the ability and opportunity to use financial knowledge and skills; *regulation_supervision* represents the regulatory and supervisory frameworks of an economy; and ΓX_{it} refers to the control variables;

the error term ε_{it} includes all other time-varying unobservable shocks to financial stability; finally, i denotes country and t denotes year.

Our first step was to gauge the relationship between fintech transactions and financial stability with and without the mediation of financial inclusion. Table 5 shows the results. As expected, we found a positive and significant effect of fintech transactions ($\beta = 0.013$; SE = 0.006; $p < 0.05$) on financial stability in Model 1. Then, to confirm the mediation, we ran Sobel-Goodman Mediation Tests using bootstrap with 1,000 repetitions. We must bear in mind that the significance of the indirect effect is a sine qua non for mediation. Still, the significance of the direct and the total effects is not (Warner, 2012). In Model 2, we can observe that the indirect effect ($\beta = -0.006$, $p < 0.05$) is negative and significant, the direct effect ($\beta = 0.019$, $p < 0.05$) is positive and significant, and the total effect ($\beta = 0.014$, $p < 0.05$) is positive and significant. These results suggest that the financial inclusion mediation between fintech transactions and financial stability is partial when both indirect and direct effects are significant. In partial mediation, the effect of the independent variable on the dependent variable occurs both directly and through the mediator.

Table 5

Regression estimates - mediation

Regression analyses explaining the effects of fintech transactions on financial stability, mediated by financial inclusion.

Variables	Model (1)	Model (2)		Model (3)	Model (4)		Model (5)	Model (6)	
	Fin. stability	Fin. inclusion	Fin. stability	Asset risk	Fin. inclusion	Asset risk	Liquidity risk	Fin. inclusion	Liquidity risk
Fintech trans.	0.013**	0.012***	0.019***	0.053*	0.012***	0.089***	1.097***	0.012***	1.323***
	(0.006)	(0.002)	(0.007)	(0.029)	(0.002)	(0.030)	(0.175)	(0.002)	(0.181)
Mediation									
Fin. inclusion			-0.465***			-2.908***			-18.561***
			(0.163)			(0.736)			(4.360)
Control Variables									
GDP growth	0.009	-0.005***	0.006	0.155***	-0.005***	0.141***	-0.763***	-0.005***	-0.849***
	(0.006)	(0.001)	(0.006)	(0.027)	(0.001)	(0.027)	(0.163)	(0.001)	(0.162)
Inflation	-0.012***	-0.004***	-0.014***	0.034**	-0.003***	0.023	0.156*	-0.004***	0.090
	(0.003)	(0.001)	(0.003)	(0.014)	(0.001)	(0.014)	(0.086)	(0.001)	(0.086)
Unemployment	-0.003	0.004***	-0.001	-0.106***	0.004***	-0.095***	-0.390***	0.004***	-0.314**
	(0.004)	(0.001)	(0.005)	(0.020)	(0.001)	(0.020)	(0.121)	(0.001)	(0.121)
Population	0.016	-0.021***	0.006	0.052	-0.021***	-0.009	-2.329***	-0.021***	-2.719***
	(0.015)	(0.004)	(0.016)	(0.069)	(0.004)	(0.070)	(0.410)	(0.004)	(0.415)
Constant	2.244***	0.430***	2.443***	2.326**	0.430***	3.575***	57.067***	0.430***	65.040***
	(0.246)	(0.059)	(0.254)	(1.114)	(0.059)	(1.146)	(6.617)	(0.059)	(6.795)
Indirect effect			-0.006**			-0.035**			-0.223**
Direct effect			0.019**			0.092**			1.343**
Total effect			0.014**			0.057**			1.121**
Observations	656	656	656	656	656	656	656	656	656
Countries	82	82	82	82	82	82	82	82	82
R-squared	0.043	0.185	0.055	0.122	0.185	0.142	0.134	0.185	0.156

Robust standard errors in parentheses. Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.1

To expand our analysis, we ran Model 3, Model 4, Model 5, and Model 6, replacing the dependent variable financial stability with two other proxies of the financial system's stability – asset risk (Models 3 and 4) and liquidity risk (Models 5 and 6). Starting with Model 3, where asset risk is estimated by bank return on assets divided by the standard deviation of ROA (ROA/SDROA), we found a positive and significant effect of fintech transactions ($\beta = 0.053$; SE = 0.029; $p < 0.1$) on asset risk. To confirm the mediation, we ran Sobel-Goodman Mediation Tests using bootstrap with 1,000 repetitions, finding similar indirect effect ($\beta = -0.035$, $p < 0.05$), direct effect ($\beta = 0.092$, $p < 0.05$), and total effect ($\beta = 0.057$, $p < 0.05$) in Model 4. We continued with Models 5 and 6, where liquidity risk is proxied by liquid assets to deposits and short-term funding (LA/DSF). In Model 5, we found a positive and significant effect of fintech transactions ($\beta = 1.097$; SE = 0.175; $p < 0.01$) on liquidity risk. In Model 6, we estimated similar indirect effect ($\beta = -0.223$, $p < 0.05$), direct effect ($\beta = 1.343$, $p < 0.05$), and total effect ($\beta = 1.121$, $p < 0.05$). These results suggest that the relationship between fintech transactions and financial stability is mediated by financial inclusion. However, the negative indirect effect suggests that, although fintech innovation has a positive total effect on the stability of the financial system, when this impact goes through financial inclusion (e.g., when fintech helps bring more unbanked people into the financial system), it ends up producing more instability to the financial sector. The results also indicate that fintech innovation adoption, when carried out by people that are already financially included, is positively associated with the stability of the financial system in both the short term and the long term. Hence, these findings support Hypothesis 1, suggesting that financial inclusion partially mediates the relationship between fintech innovation adoption and financial stability. One possible explanation for this mediation role is the fact that, although fintech is still small compared to traditional financial institutions, it

is rapidly expanding in riskier segments of the financial sector (Cevik, 2023) and, by attracting and including more underserved costumers to the financial system, it ends up bringing more instability through financial inclusion.

4.2 – Results of the contingencies for the fintech innovation-financial stability link

To investigate Hypothesis 2 – "Does financial capability affect the effect of fintech innovation on financial inclusion?", we evaluated the moderation by comparing nested models. In other words, we tested the moderation effect of financial capability on the relationship between fintech transactions and financial inclusion variables using an F-test, comparing the model without moderation (Model 7) to the model with moderation (Model 8). The results of those tests ($F = 2.98$, $p = 0.085$) suggested that we can only reject the null hypothesis (baseline nested in moderation) at a 10% level. In Table 6, we can observe that, although we were expecting that higher levels of fintech transactions would be associated with more financial inclusion when the country had higher levels of financial capabilities, the interaction coefficient ($\beta = -0.0004$, $p < 0.1$) is negative, very small and only significant at 10% level.

This negative signal may imply that financial capabilities reduce the effect of fintech transactions on financial inclusion. One possible explanation is that when underserved people are financially capable, they are more prone to decline disadvantageous financial products or services offered through fintech, reducing, to some extent, their financial inclusion. We can then argue that financial capabilities function as a protection against what Zheng (2009) calls "unfavorable

inclusion" – a type of inclusion (being connected to the financial system) but in unfavorable terms.

Table 6

Regression estimates - moderation

Regression analyses explaining the moderation effects of financial capabilities and regulation & supervision.

Variables	Model (7) Fin. inclusion	Model (8) Fin. Inclusion	Model (9) Fin. stability	Model (10) Fin. stability
Fintech transactions	0.0004	0.028*		
	(0.002)	(0.016)		
Financial inclusion			-0.155	-5.515***
			(0.204)	(1.043)
Moderation				
Financial capabilities	0.008***	0.016***		
	(0.001)	(0.004)		
Regulation & supervision			-0.019**	-0.115***
			(0.008)	(0.020)
Fintech innovation # Financial capabilities		-0.0004*		
		(0.000)		
Financial inclusion # Regulation and supervision				0.296***
				(0.057)
Control Variables				
GDP growth	-0.003*	-0.003**	0.003	0.002
	(0.002)	(0.002)	(0.007)	(0.007)
Inflation	-0.001	-0.002	-0.016***	-0.019***
	(0.001)	(0.001)	(0.005)	(0.005)
Unemployment	0.004***	0.004***	-0.013**	-0.014***
	(0.001)	(0.001)	(0.005)	(0.005)
Population	-0.011***	-0.010***	-0.020	-0.021
	(0.004)	(0.004)	(0.017)	(0.017)
Constant	-0.048	0.499*	3.487***	5.256***
	(0.091)	(0.277)	(0.401)	(0.516)
Observations	464	464	656	656
Number of countries	58	58	82	82
R-squared	0.217	0.222	0.047	0.101

Robust standard errors in parentheses.

F-tests were used to evaluate the first ($F = 2.98$, $p = 0.085$) and the second ($F = 27.38$, $p < 0.001$) moderations.

24 countries (marked with * in Table 2) were excluded from Models 7 and 8 due to data unavailability on financial capabilities.

Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In Hypothesis 3 – “Does regulation and supervision affect the effect of financial inclusion on financial stability?”, we also assessed the moderation effect of regulation and supervision on the relationship between financial inclusion and financial stability variables utilizing an F-test as well, comparing the model without moderation (Model 9) to the model with moderation (Model 10). The results ($F = 27.38$, $p < 0.001$) indicate that, at a 1% level, we could reject the null hypothesis (baseline nested in moderation). We can observe that the interaction coefficient ($\beta = 0.296$, $p < 0.01$) is positive and significant at a 1% level. This pattern supports Hypothesis 3 and suggests that the relationship between financial inclusion and financial stability is moderated by the development level of regulation and supervision of financial institutions. Countries that pursue financial inclusion with coherent regulatory and supervisory frameworks demonstrate higher financial stability.

Contrary to our expectations, our findings also show that financial inclusion has a negative and significant impact on financial stability, which suggests that the more unbanked people are included in the financial systems, the more unstable the system gets. However, due to the moderation, for every increment of one unit of supervision and regulation, the slope of financial inclusion is reduced by 0.222 unit, which means that its negative effect on the stability of the financial system is less negative. That is, gains from fintech innovation are conditional on an appropriate regulatory and supervisory framework. The results suggest that financial inclusion must be accompanied by adequate prudential regulation and supervision to ensure that only responsible financial inclusion occurs. These findings corroborate what Sahay et al.’s (2015b) work suggested: countries with strong regulation and supervision could experience financial stability gains from higher inclusion, which points to large differences in the effectiveness of

regulatory and supervisory frameworks across countries, signaling the potential risks to financial stability from an unchecked broadening of financial access.

Our last analysis concerns the first and second stage moderated mediation proposed in the conceptual framework (Fig. 1). In Table 7, Model 11 tested the conditional indirect effect using the 95% percentile bootstrap confidence intervals associated with each estimate. We can observe that the first moderation ($\beta = -0.0005$, $p < 0.1$) has a very small coefficient and is only significant at the 10% level. In contrast, the second moderation ($\beta = 0.312$, $p < 0.01$) is significant at the 1% level. The results of the indirect effect ($\beta = -0.171$, $p < 0.05$), the direct effect ($\beta = 0.021$, $p < 0.05$), and the total effect ($\beta = -0.149$, $p < 0.1$) suggest that the first and second stage moderated mediation is present (Hypothesis 4). Then, as we did in the mediation analysis, we replaced the dependent variable (financial stability) with liquidity risk (a proxy for short-term bank stability) in Model 12. We estimated both moderations ($\beta = -0.0005$, $p < 0.1$; $\beta = 4.176$, $p < 0.01$, respectively), the indirect effect ($\beta = -2.502$, $p < 0.05$), the direct effect ($\beta = 1.231$, $p < 0.05$), and total effect ($\beta = -1.271$, $p < 0.05$), which also confirmed the moderated mediation.

Table 7

Regression estimates - moderated mediation

Regression analyses explain the effects of fintech transactions on financial stability, which are mediated by financial inclusion and moderated by financial capabilities and regulation and supervision.

Variables	Model (11)		Model (12)	
	Fin. inclusion	Fin. stability	Fin. inclusion	Liquidity risk
Fintech transactions	0.028*	0.021**	0.028*	1.223***
	(0.016)	(0.009)	(0.016)	(0.234)
Mediation				
Financial inclusion		-5.894***		-87.903***
		(1.049)		(28.799)
Moderation				
Financial capabilities	0.016***		0.016***	
	(0.004)		(0.004)	
Regulation and supervision		-0.126***		-0.152
		(0.020)		(0.556)
Fintech innovation # Financial capabilities	-0.0005*		-0.0005*	
	(0.000)		(0.000)	
Financial inclusion # Regulation and supervision		0.312***		4.176***
		(0.057)		(1.554)
Control Variables				
GDP growth	-0.003**	0.005	-0.003**	-0.850***
	(0.002)	(0.007)	(0.002)	(0.191)
Inflation	-0.002	-0.018***	-0.002	0.004
	(0.001)	(0.005)	(0.001)	(0.130)
Unemployment	0.004***	-0.012**	0.004***	-0.267*
	(0.001)	(0.005)	(0.001)	(0.138)
Population	-0.010***	-0.046**	-0.010***	-1.881***
	(0.004)	(0.020)	(0.004)	(0.537)
Constant	-0.960*	7.257***	-0.960*	77.754***
	(0.536)	(0.769)	(0.536)	(21.118)
Indirect effect		-0.171**		-2.502**
Direct effect		0.021**		1.231**
Total effect		-0.149*		-1.271
Observations	464	464	464	464
Number of countries	58	58	58	58
R-squared	0.222	0.113	0.222	0.241

Robust standard errors in parentheses

24 countries (marked with * in Table 2) were excluded from this analysis due to data unavailability on financial capabilities.

Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.1

These results indicate that fintech innovation is key to increasing access to financial markets. Nonetheless, they also suggest that, even though new financial instruments and intermediaries can reduce information asymmetry and transaction costs, inappropriate financial capabilities and weak regulatory and supervisory frameworks of fintech-enabled financial inclusion can endanger financial stability, confirming García's (2016) and Demirgüç-Kunt's et al. (2022) studies. Thus, drawing on Sahay et al.'s (2020) and Cevik's (2023) research, we can argue that adopting adequate regulation and supervision and capability-building initiatives is key to strike the right balance between enabling financial innovation and addressing challenges and risks to financial integrity, consumer protection, and financial stability.

4.3 – Robustness checks

We conducted several checks to evaluate the robustness of our results. First, we used an alternative measure to quantify fintech. In the mediation analysis (Table 8), we replaced the independent variable fintech transactions with fintech adoption and ran the same tests and regressions, finding equivalent results. Model 13 shows the positive and significant effect of fintech adoption ($\beta = 0.006$; SE = 0.003; $p < 0.05$) on financial stability without mediation. To confirm the financial inclusion variable mediation, we also ran Sobel-Goodman Mediation Tests. Model 14 shows the results for indirect ($\beta = -0.001$, $p < 0.05$), direct ($\beta = 0.007$, $p < 0.05$), and total ($\beta = 0.007$, $p < 0.05$) effects. Then, we ran Model 15, Model 16, Model 17, and Model 18, replacing the dependent variable financial stability with liquidity risk (Models 15 and 16) and asset risk (Models 17 and 18). Starting with Model 15, we found a positive and significant effect of fintech adoption ($\beta = 0.274$; SE = 0.072; $p < 0.01$) on liquidity risk, So as to confirm the

mediation, we ran Sobel-Goodman Mediation Tests using bootstrap with 1,000 repetitions, finding similar indirect effects ($\beta = -0.022$, $p < 0.05$), direct effects ($\beta = 0.305$, $p < 0.05$), and total effects ($\beta = 0.283$, $p < 0.05$) in Model 16. Continuing with Model 17, we found a positive and significant effect of fintech adoption ($\beta = 0.046$; SE = 0.012; $p < 0.01$) on asset risk. In Model 18, we estimated similar indirect effect ($\beta = -0.005$, $p < 0.05$), direct effect ($\beta = 0.052$, $p < 0.05$), and total effect ($\beta = 0.047$, $p < 0.05$). The results suggest that the relationship between fintech adoption and the stability of the financial sector (proxied by financial stability, liquidity risk, and asset risk) is mediated by the financial inclusion, supporting Hypothesis 1.

Table 8

Robustness check - mediation

Robustness checks to confirm the effects of fintech transactions on financial stability, mediated by financial inclusion.

Variables	Model (13)	Model (14)		Model (15)	Model (16)		Model (17)	Model (18)	
	Fin. stability	Fin. inclusion	Fin. stability	Liquidity risk	Fin. inclusion	Liquidity risk	Asset risk	Fin. inclusion	Asset risk
Fintech Adoption	0.006**	0.002***	0.007***	0.274***	0.002***	0.297***	0.046***	0.002***	0.051***
	(0.003)	(0.001)	(0.003)	(0.072)	(0.001)	(0.072)	(0.012)	(0.001)	(0.012)
Mediation									
Fin. inclusion			-0.385**			-11.363***			-2.652***
			(0.157)			(4.314)			(0.703)
Control Variables									
GDP growth	0.011*	-0.005***	0.009	-0.751***	-0.005***	-0.811***	0.182***	-0.005***	0.168***
	(0.006)	(0.002)	(0.006)	(0.173)	(0.002)	(0.173)	(0.028)	(0.002)	(0.028)
Inflation	-0.012***	-0.004***	-0.014***	0.118	-0.004***	0.071	0.037***	-0.004***	0.026*
	(0.003)	(0.001)	(0.003)	(0.087)	(0.001)	(0.088)	(0.014)	(0.001)	(0.014)
Unemployment	-0.002	0.003***	-0.001	-0.408***	0.003***	-0.369***	-0.094***	0.003***	-0.085***
	(0.005)	(0.001)	(0.005)	(0.125)	(0.001)	(0.125)	(0.021)	(0.001)	(0.020)
Population	0.028*	-0.010***	0.023	-1.364***	-0.010***	-1.482***	0.104	-0.010***	0.077
	(0.014)	(0.004)	(0.014)	(0.390)	(0.004)	(0.391)	(0.064)	(0.004)	(0.064)
Constant	2.190***	0 .441***	2.360***	56.704***	0 .441***	61.715***	1.806***	0 .441***	2.975**
	(0.248)	(0.062)	(0.256)	(6.803)	(0.062)	(7.034)	(1.115)	(0.062)	(1.146)
Indirect effect			-0.001**			-0.022**			-0.005**
Direct effect			0.007**			0.305**			0.052**
Total effect			0.007**			0.283**			0.047**
Observations	656	656	656	656	656	656	656	656	656
Countries	82	82	82	82	82	82	82	82	82
R-squared	0.046	0.122	0.055	0.102	0.122	0.111	0.137	0.122	0.156

Robust standard errors in parentheses. Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.1

Our findings support that fintech innovation's direct impact on the stability of the financial system is positive and both statistically significant and economically relevant, suggesting that fintech contributes to enhancing decentralization and diversification, making the financial system more efficient, transparent, and competitive. On the other hand, our results also show that financial activities facilitated by fintech platforms involve greater financial instability when mediated by financial inclusion. This supports the argument that fintech exposes underserved customers to even more risks, such as fraud risk, digital risk, and discrimination risks.

To confirm Hypothesis 2, in Table 9, we ran the moderation tests using fintech adoption as the independent variable, as we did in the previous robustness check for mediation. Again, we evaluated moderation by comparing nested models, testing the moderation effect of financial capabilities on the relationship between, this time, fintech adoption and financial inclusion variables using an F-test, comparing the model without moderation (Model 19) to the model with moderation (Model 20). The results ($F = 6.23$, $p = 0.013$) indicate that the moderation, as mentioned earlier, is significant at the 5% level and with the same signal as the previous test, which supports Hypothesis 2.

Table 9

Robustness checks - moderation

Robustness checks confirming the moderation effects of financial capabilities and regulation and supervision.

Variables	Model (19) Fin. inclusion	Model (20) Fin. inclusion	Model (21) Asset risk	Model (22) Asset risk
Fintech adoption	0.002**	0.021***		
	(0.001)	(0.007)		
Financial inclusion			-3.592***	-16.878***
			(0.829)	(2.085)
Moderation				
Financial capabilities	0.007***	0.010***		
	(0.001)	(0.001)		
Regulation and supervision			-0.015***	-0.030***
			(0.005)	(0.009)
Fintech adoption # Financial capabilities		-0.0003**		
		(0.000)		
Financial inclusion # Regulation and supervision				0.206***
				(0.030)
Control Variables				
GDP growth	-0.002	-0.001	0.128***	0.106***
	(0.002)	(0.002)	(0.027)	(0.026)
Inflation	-0.001	-0.001	0.032**	0.031**
	(0.000)	(0.001)	(0.015)	(0.014)
Unemployment	0.004***	0.004***	-0.096***	-0.065***
	(0.001)	(0.001)	(0.020)	(0.020)
Population	-0.007**	-0.007**	0.147	0.108
	(0.003)	(0.003)	(0.069)	(0.067)
Constant	-0.074	-0.200**	1.713	4.803***
	(0.087)	(0.100)	(1.308)	(1.340)
Observations	464	464	656	656
Number of countries	58	58	82	82
R-squared	0.205	0.216	0.143	0.202

Robust standard errors in parentheses.

F-tests were used to evaluate the first ($F = 6.23$, $p = 0.013$) and the second ($F = 47.65$, $p < 0.001$) moderations.
24 countries (marked with * in Table 2) were excluded from Models 19 & 20 due to data unavailability on financial capabilities.

Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Likewise, as for Hypothesis 3 robustness check, in Model 21 (without moderation) and Model 22 (with moderation), we replaced the dependent variable – financial stability with asset risk and tested the moderation effect of regulation and supervision on the relationship between financial inclusion and, this time, asset risk. The results ($F = 47.65$, $p < 0.001$) suggest that the moderation is significant with the same signal as the previous tests, confirming Hypothesis 3.

Then, to check the first and second stage moderated mediation (Hypothesis 4), in Table 10, we replaced the independent variable fintech transactions with fintech adoption and ran all the same regressions. In Model 23, we kept financial stability as the dependent variable; in Model 24 (as we did previously in Model 22), we replaced it with liquidity risk. We found that our results were fully robust. The conditional indirect effect was also tested using the 95% percentile bootstrap confidence intervals associated with each estimate. In Model 23, our estimations show that both moderations ($\beta = -0.0003$, $p < 0.01$; $\beta = 0.303$, $p < 0.01$, respectively) and the partial mediation ($\beta = -0.130$, $p < 0.05$) are significant and consistent with previous tests, confirming the first and second stage moderated mediation. Likewise, in Model 24, the results indicate that both moderations ($\beta = -0.0003$, $p < 0.01$; $\beta = 3.467$, $p < 0.05$, respectively) and the partial mediation ($\beta = -1.606$, $p < 0.05$) are significant and consistent with previous tests, confirming Hypothesis 4.

Table 10

Robustness checks - moderated mediation

Robustness Checks confirm the effects of fintech transactions on financial stability, mediated by financial inclusion and moderated by financial capabilities and regulation and supervision.

Variables	Model (23)		Model (24)	
	Fin. inclusion	Fin. stability	Fin. inclusion	Liquidity risk
Fintech adoption	0.022***	0.010***	0.022***	0.283***
	(0.008)	(0.003)	(0.008)	(0.095)
Mediation				
Financial inclusion		-5.766***		-73.266**
		(1.039)		(29.149)
Moderation				
Financial capabilities	0.010***		0.010***	
	(0.001)		(0.001)	
Regulation and supervision		-0.122***		0.241
		(0.020)		(0.559)
Fintech adoption # Financial capabilities	-0.0003***		-0.0003***	
	(0.000)		(0.000)	
Financial inclusion # Regulation and supervision		0.303***		3.467**
		(0.056)		(1.575)
Control Variables				
GDP growth	-0.001	0.011	-0.001	-0.7459***
	(0.002)	(0.008)	(0.002)	(0.211)
Inflation	-0.001	-0.017***	-0.001	0.013
	(0.001)	(0.005)	(0.001)	(0.133)
Unemployment	0.004***	-0.011**	0.004***	-0.265*
	(0.001)	(0.005)	(0.001)	(0.049)
Population	-0.011***	-0.022	-0.011***	-0.476
	(0.003)	(0.017)	(0.003)	(0.468)
Constant	-0.331**	7.016***	-0.331**	60.362***
	(0.138)	(0.755)	(0.138)	(21.172)
Indirect effect		-0.130**		-1.606**
Direct effect		0.010**		0 .286**
Total effect		-0.120**		-1.320
Observations	464	464	464	464
Number of countries	58	58	58	58
R-squared	0.234	0.117	0.234	0.212

Robust standard errors in parentheses

24 countries (marked with * in Table 2) were excluded from this analysis due to data unavailability on financial capabilities.

Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.1

We also performed an instrumental variable (IV) approach to reduce further endogeneity concerns relating to omitted variables, simultaneity, and measurement error. An adequate IV should meet both the relevance condition (it requires that the instrument is correlated with the explanatory variable) and the exogeneity condition (it should not be correlated with the residuals of our main model) (Schaper et al, 2023). Our instrument variable – broadband cost, defined as the average cost in USD of a broadband Internet connection per megabit, supports both the relevance condition and the exogeneity condition. The first assumption can be verified. Our estimates indicate a high covariance between broadband cost and fintech adoption. Although the excludability assumption is more challenging to defend because it cannot be tested, we can argue that our instrument has no direct effect on financial stability, except through fintech adoption, the endogenous regressor. That is, the average cost of internet access doesn't explain the risks to the stability of the financial system, apart from its effect on fintech innovation.

By estimating a linear model specification, our findings indicate that the coefficient of the fintech innovation score is positive and statistically significant ($\beta = 0.147$; SE = 0.045; $p = 0.001$), which aligns with the positive linear effect of our main model when not using an instrumental variable approach. Again, the confidence interval (0.058|0.235) did not include zero, substantiating that the observed effect is due to chance and supporting a causal interpretation of the effect of fintech innovation on the stability of the financial system. Therefore, by focusing on the variation created by the average price of internet access, our IV strategy seeks to ensure that idiosyncratic changes in a country's level of adoption of fintech innovation that may be endogenous to its financial stability do not bias our estimates.

5. DISCUSSION

5.1 – Discussion of the findings

In this study, we empirically examined the interrelationship between fintech innovation, financial inclusion, and the stability of the financial system. For this purpose, we combined archival datasets in a balanced panel structure with 82 countries from 2013 to 2021 to test our hypothesis. The results of our regression analyses indicate that the link between fintech innovation and the stability of the financial system is partially mediated by financial inclusion, with high levels of fintech innovation leading directly to a more stable financial system. Still, when the effect of fintech on stability goes through financial inclusion (the indirect effect of the mediation), it turns negative, resulting in a reduction of stability. One possible explanation is that the way fintech innovation has contributed to including unbanked people in the financial system over the last few years is not beneficial to them and has brought even more risks to the stability of the financial system. One can argue that under very disadvantageous conditions (e.g., loans with exorbitant interest rates, high transaction fees, poor-performing investments), underserved consumers are more exposed to unnecessary risks, leading to a more unstable financial system.

Beyond that, we found that financial capabilities play a moderation role in the relationship between fintech innovation and financial inclusion, and the regulatory and supervisory frameworks are strong moderators in the relationship between financial inclusion and the stability of the financial system. Regarding this first moderation, our findings indicate that financial capabilities reduce the effect of fintech transactions on financial inclusion, which serves

as a barrier against unfavorable financial inclusion. In the second moderation, our results suggest that coherent regulatory and supervisory frameworks attenuate the negative impact of financial inclusion on financial stability, which can harness fintech benefits while mitigating risks to financial stability. We can argue that ensuring financially underserved individuals benefit from fintech-driven financial inclusion requires appropriate regulations and vigorous consumer protection safeguards. Table 11 summarizes the four hypotheses and the results of our estimations.

Tabel 11 – Hypothesis result summary

Hypothesis	Description	Results
H1 – Mediation	Financial inclusion partially mediates the relationship between fintech innovation and financial stability.	Financial inclusion partially mediates the relationship between fintech innovation and financial stability. Fintech innovation, when carried out by financially included people, is positively associated with financial stability in both short and long terms. However, when this impact goes through financial inclusion (e.g., when fintech helps bring more unbanked people into the financial system), it ends up producing more instability to the financial sector.
H2 – First Moderation	The relationship between fintech innovation and financial inclusion is moderated by individuals' financial capabilities. It is positive (negative) for countries with high (low) levels of individuals` financial capabilities.	Financial capabilities moderate (reduce) the effect of fintech transactions on financial inclusion. Financial capabilities function as a protection against unfavorable financial inclusion (inclusion in unfavorable terms).
H3 – Second Moderation	The relationship between financial inclusion and financial stability is moderated by regulatory and supervisory frameworks. It is positive (negative) for countries with more (less) robust regulatory and supervisory frameworks.	Regulatory and supervisory frameworks moderate (reduce) the effect of financial inclusion on financial stability. Countries that pursue financial inclusion with coherent regulatory and supervisory frameworks demonstrate higher financial stability.
H4 – First and Second Stage Moderated Mediation	The mediating role of financial inclusion in the relationship between fintech innovation and financial stability is moderated by financial capabilities and regulation and supervision.	The first and second stage moderated mediation is present. Inappropriate financial capabilities and weak regulatory and supervisory frameworks of fintech-enabled financial inclusion can endanger financial stability.

5.2 – Contribution to financial innovation and technological innovation research

Our study contributes to the literature on financial innovation and technological innovation in at least four substantial ways. Firstly, it builds upon previous research that has investigated how fintech innovation affects countries' financial stability (e.g., Daud et al., 2022; Fung et al., 2020), the effects of fintech adoption on the fragility of financial intermediaries and institutions (e.g., Cevik, 2023; Elekdag et al., 2024), the link between financial deepening and the stability of the financial sector (e.g., Hua et al., 2023; Morgan and Pontines, 2014; Siddik and Kabiraj, 2018), and how financial inclusion affects the stability of the banking system (e.g., Danisman and Tarazi, 2020; Han and Melecky, 2013). Table 12 summarizes the topics explored and the main findings in our systematic literature review. Although these studies have contributed to deepening our understanding of how technological innovations in the financial industry influence risk-taking by financial institutions and the synergies and tradeoffs between financial development and financial stability, especially in times of financial stress, they have overlooked the influence of financial inclusion in the relationship between financial innovations and the stability of the financial sector.

Table 12 – Research themes and main findings

Themes	Sub-themes	Main findings
Financial inclusion	The economic divide	A lack of access to financial services is not just a symptom of the wealth gap but is also a cause. Without the ability to affordably save, invest, and insure themselves against risks, financially underserved families struggle to translate the income they earn into wealth.
	Financial wellness	Financial inclusion helps underprivileged individuals achieve financial health and wellness, greater resilience, and savings for adverse shocks so that they can deal with unfortunate events, such as healthcare expenses, natural disasters, or unemployment.
	Fintech-driven financial inclusion	Fintech is a promising avenue for reducing inequality in access to financial services by resorting to emerging technologies, such as blockchain, biometrics, big data analytics, and artificial intelligence.
	The financial inclusion dilemma	Financial inclusion can be at risk as digital services accelerate in the post-COVID era, driven by unequal access to digital infrastructure, differences in financial and digital capabilities, and potential biases (e.g., in algorithms) amplified by new data sources and data analytics.
	Regulatory and supervisory frameworks	To manage the trade-off between financial inclusion and financial stability, adequate prudential regulation and supervision must ensure that only responsible financial inclusion occurs. Sound policy design is needed to ensure that fintech is used in a responsible and equitable way.
Inclusive innovation	Inclusive innovation *versus* solutionism	Inclusive innovation is a response to the perception that the innovation process is often a mere contributor to increasing social exclusion and the economic divide.
		Inclusive innovation should create reasonable offerings for marginalized segments of society, providing affordable financial products and services that meet their demands.
	Technology-enabled innovations in financial services	Fintech suggests that it is possible to reconcile the inclusive direction of innovation and financial advancements, which might represent a game-changer in the reputation and inclusiveness of financial innovation.
Financial innovation	Fintech revolution	Through financial inclusion, Fintech can help the financial industry achieve some UN SDGs, specifically, no poverty, zero hunger, economic growth, and reduced inequalities.
	Flip side of fintech	Fintech can jeopardize financial inclusion by exposing underprivileged people to mathematical models that reinforce discrimination or by offering only products and services mainly designed for banked customers, increasing inequality.
	Financial capability gap	Uneven access to the needed physical infrastructure or insufficient financial capabilities could create a new source of digital exclusion, notably among women, the poor, those living in rural areas, and the elderly. National financial capability-building strategies are necessary to maximize the benefits of financial inclusion.
Financial stability	Fintech and financial stability	The 'innovation-growth' and 'innovation-fragility' perspectives have opposing views on whether the influence of financial innovations on the financial system is broadly positive.
	The impact of the COVID-19 pandemic on the fintech landscape	Fintech firms have played an important role in mitigating the economic impact of the pandemic by helping governments reach—quickly and securely—people and businesses with various forms of income and liquidity support.
		The lack of access to the necessary digital infrastructure could lead to new forms of financial exclusion, which may be exacerbated as the shift to digital financial services accelerates during and post-COVID-19 as the initial findings suggest.

Hence, our study sought to explore this gap by proposing and empirically testing a conceptual model of the effects of fintech innovation on financial deepening and financial stability. We theorized and found that the relationship between fintech adoption and the stability of the financial system is partially mediated by financial inclusion. Our findings contribute to clarifying the potential of fintech innovation to integrate financially excluded people into the formal financial system and the influence of such inclusive and financial innovation on financial risks.

Secondly, although previous research has highlighted the relevance of the level of financial capability-building initiatives (Demirgüç-Kunt et al., 2022; Lusardi and Mitchell, 2014) and regulatory and supervisory frameworks (Arner et al., 2020; Sahay et al., 2015b) for country-level stability outcomes, it has devoted little attention to the contexts in which financial capabilities and regulation and supervision play essential roles in the interrelationship between fintech innovation, financial inclusion and financial stability. Our study confirms that the link between fintech innovation and financial stability is more complex than previously assumed. However, our study moves further by suggesting that countries that want to benefit from fintech innovation without jeopardizing the financial system's stability must skillfully navigate the level of financial capability-building initiatives and regulatory and supervisory frameworks in their fintech landscape development.

Thirdly, previous studies on fintech adoption are incipient and mostly focus on data on specific countries or regions (e.g., Allen et al., 2020; Banna et al., 2022; Geng et al. 2023; Natile, 2020; Suri and Jack, 2016; Van and Dubus, 2019), which has further limited the literature's empirical

basis for external validation and theoretical inferences about causal effects on financial stability. Our study contributes to bridging this gap by deepening the understanding of the financial stability and financial inclusion implications of fintech innovation worldwide. A global perspective is crucial in inclusive innovation studies because it provides a comprehensive understanding of diverse market dynamics and underprivileged consumers' behavior. By examining fintech adoption across different countries, researchers can identify universal trends and unique challenges, leading to more effective and inclusive strategies and policies supporting global financial inclusion without jeopardizing the financial system. Specifically, moving further relative to the existing literature on fintech-driven financial inclusion, our comprehensive approach with wide geographical coverage and reliable datasets ensures the representation of a diverse range of countries and financial indicators, presenting a valuable contribution to expand research on the advent of inclusive innovation and its interaction with technological innovation and economic development worldwide.

Finally, our results corroborate Morales et al.'s (2023) proposal for an 'inclusive innovation system' that promotes transformative innovation policies, prioritizing sustainability and confronting social and financial exclusion. Our findings suggest that the inclusive direction of innovation (Bell and Figueiredo, 2012; Pansera and Owen, 2018) can benefit from fintech adoption provided coherent regulatory and supervisory frameworks and effective financial capability-building initiatives are in place. We argue that these financial instruments are essential to harness the potential of fintech innovation to promote favorable financial inclusion while stimulating steady economic growth. Thus, our study contributes to helping policymakers manage long-standing risks and maximize fintech innovation's economic and social benefits.

Striking the right balance between trade-offs at every step of fintech development remains fundamental to fostering innovation while mitigating excessive financial risks.

5.3 – Practical policy implications

Our study yields important implications for policymakers and related practitioners, especially ensuring that fintech is used responsibly and equitably. Firstly, our findings indicate that reaping the potential benefits of fintech innovation requires preparation. Thus, sound policy design needs to start with assessing the fintech landscape, its risks, regulatory gaps, and financial and digital infrastructures to calibrate to country-specific conditions appropriately.

Secondly, we must remember that societies face many global issues and challenges today, including the climate crisis, poverty and hunger, pandemics, health care, and digitization, can only be solved collaboratively through cooperative innovation processes (Schäper et al., 2023). Given the international nature of fintech, effective supervision requires greater collaboration and coordination in developing common standards and regulatory principles (Cevik, 2023; Elekdag et al., 2024). In that sense, we recommend that policymakers stimulate interagency and cross-border cooperation to support a sound regulatory and supervisory response to fintech, striking the right balance between fostering financial innovation and implementing effective financial consumer protection practices.

Thirdly, a successful national financial capability-building strategy can also preclude underserved segments of society from taking unnecessary risks associated with over-

indebtedness, social exclusion practices, and reinforcement of information asymmetries. More importantly, those policies should keep pace with the speed of innovation and related threats, including cybersecurity risks, amplifying market volatility, compounding aggregate risk-taking and contagious behavior among consumers.

Finally, regarding the stability of the financial system, policymakers should consider modernizing legal principles and macroprudential policies, as well as expanding the scope of existing regulations, to prevent a build-up of systemic risks in the financial sector by fast-growing fintech activities (Cevik, 2023). Therefore, our analyses and results have the potential to serve as inputs to the design, modification, and implementation of corporate strategies and public policies to stifle fintech innovation and financial inclusion without jeopardizing the stability of the financial system.

5.4 – Limitations and future research suggestions

Like all research, our study inevitably has some limitations. The first limitation comes from the literature data selection and extraction. Although the method of systematic review is advantageous in selecting works from an unbiased perspective, subjective aspects are involved in determining scholarly sources, defining search terms, and refining criteria for literature data. Some influential papers might have been excluded if they were not indexed by the two databases or written in other languages. By focusing on empirical studies published in peer-reviewed journals, we may have overlooked other relevant articles published in books that could deepen the understanding of financial inclusion by fintech. In addition, in the emerging field of fintech

innovation, technologies and applications are constantly evolving, and research is advancing, leading to a multiplication of literature. These factors have led to the emergence of new research directions. Therefore, our literature review was exploratory (Zou et al., 2023).

The second limitation stems from its set of countries and the time considered. Since data scarcity was one of the main challenges we faced in addressing our hypotheses, future research could revisit our fintech innovation measures and explore alternative datasets, financial inclusion indexes and financial risks. Finally, our study's objective is limited to assessing the effect of fintech innovation on financial inclusion and its mediating effect on the relationship between the stability of the financial system and fintech innovation. Nascent, but rapidly evolving digital financial services which are often based on distributed ledger technology such as crypto-assets, stablecoins, central bank digital currencies, Decentralized Finance (DeFi), and tokenized assets (World Bank, 2022a), are beyond the scope of this thesis. Nonetheless, it would be interesting to assess the participation of bigtech firms in financial inclusion and inequality reduction. Another possibility is the potential of central bank digital currencies (CBDCs) to advance financial inclusion notably in emerging markets and developing economies. Future research could also include the implications of financial capabilities on poverty alleviation. Examining such effects in future research can be critical to scholars, practitioners, and policymakers. To contribute to future research directions, Table 13 summarizes the main gaps in finance and innovation management literature and suggests areas for further study.

Table 13 – Future research directions

Some gaps in extant studies	Suggested areas for further research	Potential research questions
The macroeconomic effects of financial inclusion	The driving factors of financial inclusion (both digital and traditional)	To what extent have financial inclusion initiatives benefited women, rural populations, and marginalized adults?
		How do Big Tech companies' economies of scale and massive data holdings impact financial inclusion?
		Does financial inclusion affect more underprivileged people than a middle-class and wealthy segment of society?
	The potential impact of financial penetration onthe stability of the financial system	How does financial inclusion affect economic growth and poverty reduction?
		What are the synergies and trade-offs between financial inclusion and financial stability?
The impact of financial innovations on achieving the United Nations' Social Development Goals	The dilemma between enabling financial innovation and addressing challenges and risks to financial integrity, consumers' protection, and financial stability	Do fintech providers exacerbate economic crises, destabilizing the financial systems during economic downturns?
		Can central bank digital currencies support the digital economy and promote financial inclusion?
		How are atomization, unbundling, and rebundling reshaping business models, product economics, and the provider landscape?
	The impact of the COVID-19 pandemic on the financial landscape	How did the COVID-19 pandemic affect the adoption and further innovation in finance?
	The potential of central bank digital currencies (CBDCs) to advance financial inclusion notably in emerging markets and developing economies	What is the role of CBDCs in poverty alleviation and inequality reduction in emerging markets and developing economies?
Fintech potential to promote financial inclusion in developed and developing economies, particularly for disadvantaged individuals.	The impact of fintech on different regions and populations.	Can fintech providers mitigate financial exclusion by enhancing transparency and reducing information asymmetry?
		To what extent is the fintech revolution different from previous interlinkages of finance and technology?
		What are the fundamental drivers of the current fintech wave?
	The flip side of fintech	Does fintech algorithmic decision-making promote or inhibit discrimination?
		Do financial innovations enrich elites at the expense of impoverished people while also shifting risks to the poor?
		Can machine learning improve credit market efficiency without increasing unwarranted human biases against minorities?

Table 13 – Continued

Some gaps in extant studies	Suggested areas for further research	Potential research questions
The interrelationship between fintech innovation, financial inclusion, and financial stability at the cross-country level	The role of fintech innovation and financial inclusion in promoting inclusive development	What are the factors that either expand or restrict financial inclusion for underprivileged groups through fintech?
		What factors can enhance or undermine the financial system's stability using fintech?
	The factors that moderate the interrelationship between fintech innovation, financial inclusion, and financial stability	How do financial capabilities affect the connection between fintech, financial inclusion, and financial stability?
		How do **r**egulatory and supervisory frameworks affect the interrelationship between fintech, financial inclusion, and financial stability?
	The dilemma between enabling financial innovation and addressing challenges and risks to financial integrity, consumers' protection, and financial stability	How can financial innovations address the increasing demand for digital services, financial inclusion, savings for aging populations, and greener initiatives?
The potential effects of financial capability on financial inclusion and whether they lead to financial wellness improvements	The development of individuals' financial capabilities	Do countries with varying financial capabilities experience different effects from financial innovations on financial inclusion?
		How do financial capabilities influence the interrelationship between fintech, financial inclusion, and financial stability?
		Why is building individuals' financial capability to access bank accounts and financial services important?
	The implications of financial capabilities for poverty alleviation	What are some of the ways that financially challenged adults can benefit from programs that improve their financial capabilities?
Impact of regulatory measures and oversight on the interplay between inclusivity and stability.	The calibration of the regulatory and supervisory frameworks for financial service	Do countries with varying levels of financial regulation and supervision experience different effects of financial inclusion on stability?
		How should financial systems manage the trade-off between inclusion and stability?
	The role of regtech and suptech in the sustainable development of fintech	Should regulators resort to technologies, such as regtech and suptech, to respond to fintech development?

6. CONCLUSION

Our study focuses on articulating the potential of fintech to promote access to financial products and services and to offer unparalleled opportunities for the unbanked population while reconciling financial stability. We also discuss new directions for innovation and the contribution of inclusive innovation to financing. Understanding the extent and impact of fintech on financial inclusion and stability can provide useful theoretical insights into knowledge-inclusive innovation in general and fintech in disadvantaged markets, especially in emerging economies.

We have to bear in mind that financial inclusion is not just a function of availability and access to the financial system for low-income people and firms, giving them a path to the digital economy. It is also a function of sustainable usage of financial products/services and financial capabilities to benefit from those financial opportunities. Access is only the first step towards full financial inclusion and a means to the greater good. The narrative that the so-called “fintech revolution” can curb alone financial exclusion should be viewed with caution. Fintech should not be perceived as the new panacea for financial deepening. Its effect is significant and relevant but limited. Other factors, such as digital financial infrastructure, financial and digital capabilities, and inclusive strategies and public policies also play a crucial role in broadening financial access to underserved segments of society. Ultimately, the goal is to ensure that this access helps disadvantaged people achieve financial health and well-being, become more resilient, and save for negative shocks to cope with unfortunate events such as health care costs, natural disasters, or unemployment. The key is to give people access to the financial system and the digital economy

and ensure they have the products, services, and skills they need to follow this path to financial health and wellness.

In this study, we discussed and empirically tested the benefits and costs of fintech innovation, arguing that the relationship between the degree of fintech adoption and the stability of the financial system is mediated by financial inclusion. We further proposed that this pattern depends on the moderation roles played by individuals' financial capabilities and countries' regulatory and supervisory frameworks, which aims to assist researchers and policymakers in designing effective interventions that promote socio-economic integration and financial stability. The results of our moderated-mediation regression analyses support our theorizing. Overall, our study contributes significantly to the literature on financial innovation and technological innovation by promoting a more comprehensive scholarly analysis, elaborating on and showing the financial stability and financial inclusion implications of fintech innovation, discussing the merits and risks of fintech adoption, and advancing a more contextualized view of fintech innovation by better understanding financial capabilities and regulation and supervision as critical factors of its interrelationship with financial inclusion and risks associated with the stability of the financial sector. We sought to contribute to helping policymakers promote inclusive innovation as a tool to shape the innovation system's structure and dynamics to uphold equitable economic growth and social cohesion.

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