The Fintech Ecosystem and Financial Inclusion: Evidence from Kenya

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The Fintech Ecosystem and Financial Inclusion: Evidence from Kenya

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Abstract

Motivated by calls to examine whether fintech fosters effective financial inclusion, we examined how consumer engagement with the fintech ecosystem affects access to traditional financial services. Using the FinAccess Kenya Household Survey 2021 data, we constructed a novel metric of individual engagement with the fintech ecosystem and investigated how it is associated with consumption of formal traditional financial products at the microlevel. Deploying a battery of econometric procedures, we have provided robust evidence that individual engagement with the fintech ecosystem is positively associated with use of formal traditional financial products. The positive impact of individual engagement with the fintech ecosystem on their use of traditional financial products is transmitted though reduction of the distance barrier and by fostering the consumption of financial products by traditionally disfavoured population segments. We have provided several policy guides anchored on these findings.

Keywords: *Fintech ecosystem: financial inclusion; financial products; Kenya; logistic regression*

JEL Classification: *G20; G100; J16; O17*

1. Introduction

Many recent studies have attributed financial inclusion to various facets of the fintech ecosystem such as mobile money (e.g., N'dri and Kakinaka, 2020; Bollaert et al., 2021) without necessarily interrogating the nature of financial inclusion inferred. Consider a self-employed young man living in Nairobi, Kenya. His aunt lives in a rural village away from Nairobi. Suppose that both the young man and his aunt own and use mobile money accounts (i.e., engage with the fintech ecosystem). The young man remits money to his aunt via their mobile money accounts when she suffers a cash flow deficit. Thus, provided the young man remains self-employed, their mobile money accounts help his aunt to smooth her consumption (e.g., Suri and Jack, 2016). Thus, due to their ownership and use of mobile money accounts, some studies (e.g., Shaikh et al., 2023) may infer that the young man and his aunt are both financially included.

Yet, questions arise regarding the nature of their inclusion. Can the young man access formal credit, for example, courtesy of his mobile money account (e.g., credit to grow his business)? Suppose a misfortune strikes and the young man's enterprise fails, can his aunt rely on her mobile money account for consumption smoothing? That is, is the aunt's mobile money account sufficient to facilitate her consumption smoothing without her nephew's support? These questions essentially speak to the differences between formal usage (involving at least one regulated financial institution or market) and informal usage (involving only non-regulated institutions) of financial products (Johnen and Mußhoff, 2022). For example, individuals may consume digital credit from a multitude of non-regulated lenders operating in Kenya (Gwer et al., 2019), directly from regulated institutions (e.g., banks) or indirectly through their partnerships with mobile service providers. According to Demirgüç-Kunt and Klapper (2013) and World Bank (2014), only individuals who use formal financial services of regulated institutions are considered (effectively) financially included[1].

In the spirit of Demirgüç-Kunt and Klapper (2013), we argued that although certain usages of products in the fintech ecosystem (e.g., money remittance, informal digital credit) are sometimes interpreted as financial inclusion (Shaikh et al., 2023) due to their short-term benefits (e.g., consumption smoothing of the kind described in the introductory paragraph), they may not have the welfare impacts (N'dri and Kakinaka, 2020) often associated with usage of formal financial products (e.g., savings,

insurance). To illustrate, when available, informal digital credit usually comes with high interest rates[2], the continual usage of which may lead to debt overload (Brailovskaya et al., 2021), and loan amounts that are often too low to foster positive change in users' lifestyles, compared to formal credit (Johnen et al., 2021). Consequently, fintech has been criticized as being designed to satisfy the profiteering incentives of the supply side[3].

The misalignment of incentives that critics point out would be mitigated if the fintech ecosystem fostered usage of formal (conventional and digital) financial products of regulated financial institutions which, additionally, promote responsible financial behaviour (e.g., by pegging credit to applicants' incomes) and avail professional financial advice to their consumers[4]. That is, we argue that the fintech ecosystem should capacitate individuals to enjoy greater intensity in the use of formal financial products beyond 'mere' access to remittance and payment platforms. Thus, the central theme of this paper was to ascertain, using Kenya's data, if individual engagement with the fintech ecosystem (e.g., ownership of a mobile device and using it to consume fintech services) can explain individual consumption of formal financial products.

This is important given that the literature documents a close link between the usage of such products and individual welfare (e.g., N'dri and Kakinaka, 2020; Chakrabarty and Mukherjee, 2021). That is, we tested the implications of the contention of Arner et al. (2020) that ultimately, the real opportunity afforded by fintech is that it develops an "infrastructure for a digital financial ecosystem that underpins financial inclusion." A close linkage between consumption of formal financial products and welfare is consistent with the maxim that financial inclusion is about the utility of financial products in "improving financial autonomy and capabilities" of often marginalized groups such as rural dwellers, and women (Muralidhar et al., 2019).

To address the issues posed by this study, we started by proposing a construct that represents individual engagement with the fintech ecosystem (a microlevel indicator of fintech ecosystem usage). The construct, arguably the main innovation of this study, is enabled by operationalizing recent conceptual proposals of Kangwa et al. (2020). The proposals, and hence the construct, are informed by the understanding of the fintech ecosystem as a network of relationships in which interrelated parties (i.e., service providers, regulators and customers), each pursuing their separate objectives, interact with each other through consumption, partnerships, intermediation and regulatory linkages in ways that yield outcomes that are superior to those realizable when individual players act separately (Oborn et al., 2019). The fintech ecosystem exploits technological advances (e.g., digital infrastructure and data analytics) to foster the provisioning of financial services. The readiness for and ability of individuals to access and consume the products of these technological advances essentially constitute the fintech ecosystem at the microlevel.

We deployed this construct to explore the interesting linkage between individual engagement with the fintech ecosystem and usage of formal financial products of regulated institutions and markets in Kenya. Kenya is an appropriate laboratory for testing the implications of the fintech ecosystem for financial inclusion for several reasons. First, Kenya is the pioneer of mobile money technology (Jack and Suri, 2014) and has witnessed notable expansion in the fintech sector in recent years (Bachas et al., 2018), with many innovations around the mobile wallet concept. Second, the country ranks first in Africa and second only to China in the world, in mobile payment usage, with transactions via mobile wallets and phones amounting to about 87% of its gross domestic product (GDP)[5]. The linkages are examined using the 2021 FinAccess Kenya Household Survey data (KNBS/CBK/FSD, 2021).[6] Because the survey was specifically designed to measure financial inclusion, it covers many of its facets. The survey also provides information on individual characteristics that are useful for exploring potential heterogeneities.

The study makes several contributions to literature. First, we have provided evidence relating to the intensity of consumer engagement with the fintech ecosystem to financial inclusion rather than the supply side (e.g., businesses such as telcos and banks extending services through digital platforms) as is the norm in the empirical literature (e.g., Aziz and Naima, 2021; Morgan, 2022; Shaikh et al., 2023). To the best of our knowledge, this paper is not only the first to explore the fintech ecosystem from consumer perspectives, but also the first to develop a construct specifically to appreciate how individual engagement with the fintech ecosystem informs consumption of mainstream financial products. In this regard, we have documented a robust positive relationship between the use of formal financial products (credit, savings, insurance and investments) and individual engagement with the fintech ecosystem. Specifically, the results show that engagement with the fintech ecosystem is associated with an increase in the probability of usage of formal financial products by at least 0.8 percentage points after controlling for various socio-economic characteristics and endogeneity.

Second, we have provided evidence on reasons for Kenyans' engagement with the fintech ecosystem. First, Kenyans engage with the fintech ecosystem to build a reliable financial transactions history that enables them to access formal financial services by reducing information asymmetry between them and lenders. Second, the distance barrier is as much a disincentive to the use of the fintech ecosystem as it is to physical branches/agents of financial institutions. Nevertheless, the fintech ecosystem tends to address the distance barrier in accessing and using formal financial products, perhaps because some of such services are now commonly available in digital formats, which lowers the transaction costs associated with their consumption when supplied through conventional channels (e.g., at physical bank branches). Finally, engagement with the fintech ecosystem falls by at least 21% if an individual lives in northern Kenya, where physical infrastructure is relatively underdeveloped.

Third, we sought to establish the demographic profiles of the key beneficiaries of the fintech ecosystem as a financial inclusion enabler. Results showed that engagement with the fintech ecosystem is associated with an improvement in the consumption of capital market products, interestingly, for women, and older adults (individuals aged at least 35 years). That is, relative to those who do not engage with the fintech ecosystem, traditionally disfavoured individuals who engage with the fintech ecosystem tend to enjoy higher usage of securities market products (e.g., investments in capital market securities, such as equities, bonds and/or portfolios formed from them, which serve the important consumption smoothing role).

The balance of this paper proceeds as follows. The relevant literature is reviewed in Section 2, which also states the study's hypotheses. Section 3 highlights and briefly describes stylized facts on the fintech ecosystem and financial inclusion in Kenya. Section 4 presents the data and addresses measurement of the variables and constructs. The empirical strategy is outlined and executed in Sections 5. Section 6 concludes.

2. Literature review and hypotheses

Recent studies employing Kenyan data document a strong role for various aspects of the fintech ecosystem on financial inclusion. For example, Kim (2020) found that mobile money has improved the quality of life of the poor in Nairobi by providing a savings service that better suits their needs, enabling them not only to save but to do so more frequently. Similarly, Ntwiga (2019) found that the consumption of credit is influenced by perceptions on cost, trust, source of financial advice and financial literacy, and that fintech intervention positively influences these perceptions. Mallinguh et al. (2017) observed that the launch of M-Pesa ignited a remarkable digital revolution in Kenya, whose result has been a merger of mobile and financial services that has improved connectivity, expanded financial inclusion, and pressured the government to address cyber-security threats, address the provisioning of relevant infrastructure, and develop an enabling regulatory environment. These studies, like most in the recent literature (e.g., Riley, 2018; Kim, 2020; Dizon et al., 2020; Aziz and Naima, 2021; Morgan, 2022; Shaikh et al., 2023), focused only on one aspect of fintech and neglected other facets of the multi-dimensional fintech ecosystem, thereby downplaying the equally important fintech consumers.

The World Bank (2014) argued that mobile payment services should not be an end in themselves, and that financial inclusion should be inferred only when an individual uses a multiplicity of intermediated financial services. Consistent with this observation, Osoro and Muriithi (2018), when analysing the relationship between fintech and financial inclusion in Kenya, made a case for going beyond the mobile payment services and incorporating "deeper usage" of financial services. Our study responded to this call by examining whether individual engagement with the fintech ecosystem was associated with effective financial inclusion.

Built on emerging digital technologies, the fintech ecosystem enables supply-side actors to specialize in the provisioning of services in which they have comparative advantage, which lowers the aggregate cost of provisioning of the interrelated services (e.g., Riley, 2018), widens the reach of financial services (World Bank, 2014), and improves trust on the demand and supply sides of the financial services market, thereby benefitting the underprivileged by bringing them into the formal financial system where they can realize welfare gains from increased consumption of financial products (Rauniyar et al., 2021)[7]. For example, commercial banks could provide services directly (through traditional channels such as banking halls) or by partnering

with telcos to use mobile service platforms, with such partnerships fostering access to remote locations and lowering their costs of service provision (e.g., by eliminating the need for leasing of premises and investing in branches). The resulting lower costs should foster consumption of formal financial services (e.g., lower cost of loan applications). Thus, it is sensible to argue that higher levels of usage of formal financial products (e.g., credit in the foregoing example) should be achieved through greater fintech ecosystem engagement. Thus, our first hypothesis was stated as follows:

H1: Engagement with the fintech ecosystem increases the consumption of formal financial products.

The literature has identified several channels through which the fintech ecosystems could influence usage of formal financial products. In Kenya, where the informal sector creates at least 83% of total employment[8], a large proportion of the active labour force works in the informal sector, earning daily wages. In such cases, physical access to financial institutions may entail high costs, including opportunity costs of lost daily wages, travel costs (Muralidhar et al., 2019) and the normal services charges. For such individuals, these costs collectively constitute transaction costs[9] and, considered relative to the value of their typical financial transaction (usually small in absolute terms), increase the average transaction cost considerably. Because digital financial services help save costs such as travel and lost earnings, the fintech ecosystem may help lower the average transaction costs for such individuals (see, e.g., O'Neill et al., 2017) by minimizing travel expenses and lost earnings. This may address the problem of access to formal financial services (e.g., owning a bank account) without usage (e.g., saving). Thus, we stated the study's second hypothesis as follows:

H2: The fintech ecosystem alleviates the distance barrier to the usage of formal financial products.

For low-income individuals whose earnings and expenditures are largely cash-based, and hence unrecorded, the fintech ecosystem goes beyond lowering transaction costs. In their case, digital technologies such as mobile money present the additional benefit of leaving an electronic trail which is not only transparent (Muralidhar et al., 2019) but also establishes a financial history (O'Neill et al., 2017). Facilitated by data analytics, digital transaction history plays a key role in credit evaluation (Philippon, 2019)[10]. The practicality of using digital transaction records has been demonstrated by institutions, such as Orange Bank Africa, that have adopted innovative ways of credit appraisal that utilize customer data on mobile money transactions[11]. The third hypothesis of the study therefore was:

H3: The fintech ecosystem mitigates the transaction history barrier to the usage of formal financial products.

Subramaniam (2020) grouped the digital ecosystem into two subcomponents: production (supply-side) ecosystems, which exploit data connectivity availed by digital technologies to shape interdependencies founded upon traditional value chains; and consumption (demand-side) ecosystems, which are largely non-traditional interdependencies founded upon data generated by digital technology-driven product usage. Both ecosystems may play an important role for financial inclusion. For example, on the supply side, subject to government agencies providing a conducive regulatory environment, innovative fintech start-ups could transform and unbundle traditional financial services to create highly personalized products that target specific consumer preferences and needs (Senyo et al., 2022). Indeed, as Gabor and Brooks (2017) observed, through big data and data analytics, service providers (e.g., fintech start-ups and banks) understand the risk profiles of users, which enables them to channel appropriate products to potential consumers. This informed our fourth hypothesis:

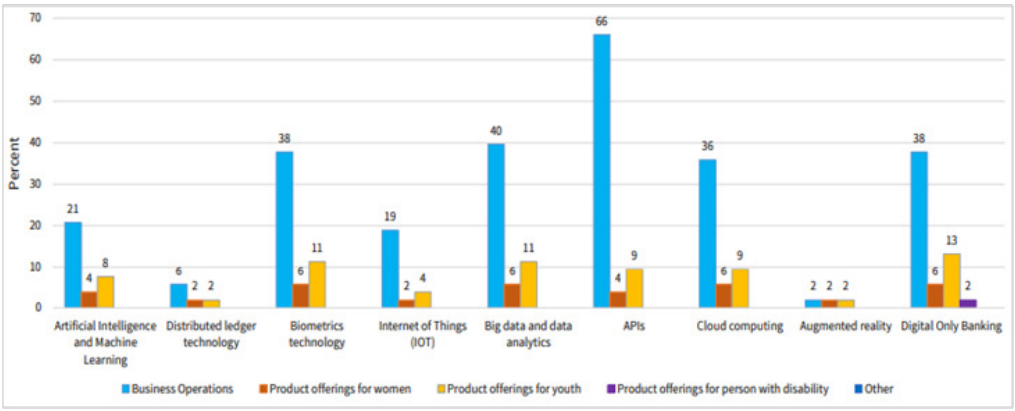
H4: The fintech ecosystem promotes financial inclusion by provisioning appropriate financial products.

A study that is probably the closest to ours, Kangwa et al. (2020), found that financial inclusion is the result of the complex adaptive behaviour of the fintech ecosystem and recommended that the development of inclusive financial business models should consider the clientele's digital consumerism, especially in sub-Saharan Africa where there has been a boom in youthful tech-savvy consumers. Although desirable for the fintech ecosystem to influence financial inclusion, digital consumerism is difficult to achieve in an environment with constraints. Potential consumers of digital finance often have limited capabilities due, say, to supply-side constraints (e.g., unavailability of a stable, affordable Internet connection) and demand-side constraints such as inadequate requisite skills, such as literacy and computer proficiency (SKOLKOVO, 2015). We incorporated these constraints in the proposed microlevel fintech ecosystem construct.

3. Stylized facts

The fintech ecosystem in Kenya has witnessed remarkable growth since the launch of the revolutionary M-Pesa digital money transfer platform in 2007. Available data show that the value of mobile money transactions conducted through agents during July 2022 stood at KES 722.52 billion[12], equivalent to about 6% of the country's GDP, having grown from KES 1.07 billion in July 2007. The country had at least 385 registered fintech firms and start-ups by July 2022 operating in various fintech subspaces such as savings and credit, foreign exchange and cryptocurrency, insurance, and micro/neo-banking[13]. Additionally, the traditional banking subsector has increasingly become an important player in the fintech ecosystem (Bollaert et al., 2021), as Figure 1 shows. For example, about 38% and 40% respectively of Kenyan banks use digital-only banking and big data and data analytics, and 68% use application-product interfaces (APIs).

Figure 1: Kenyan banks' utilization of technology in product offerings



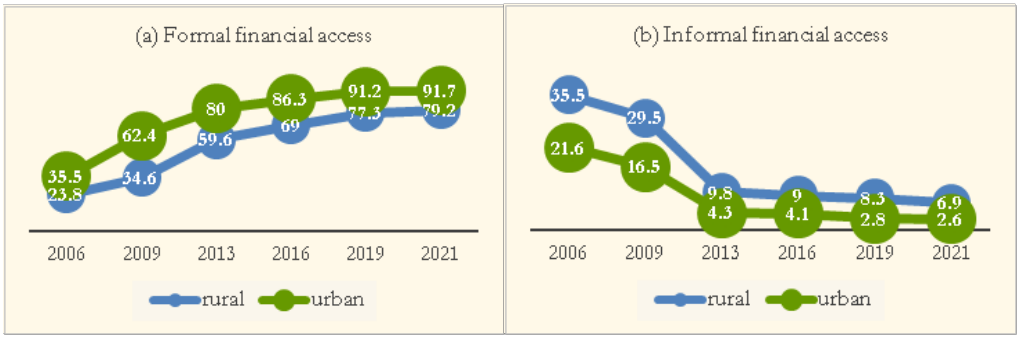
Source: Central Bank of Kenya[14]

Indeed, the Central Bank of Kenya's (CBK) 2021 Banking Sector Innovation Survey reported that banks' reliance on analytics (based on data gathered from social media) to understand customer needs and feedback grew by 74% during 2021, replacing exploratory customer interviews, hitherto the preferred feedback and "intel" channel. Consistent with the growth in the usage of the fintech ecosystem, anecdotal evidence, based on data from the 2021 FinAccess Kenya Household Survey also showed remarkable growth in financial inclusion in the country since

2006. To illustrate, Figure 2 indicates a steady growth in the overall access to (and possibly consumption of) formal financial services since 2006 when the survey was first carried out. Conversely, access to informal financial services has fallen steadily over the period.

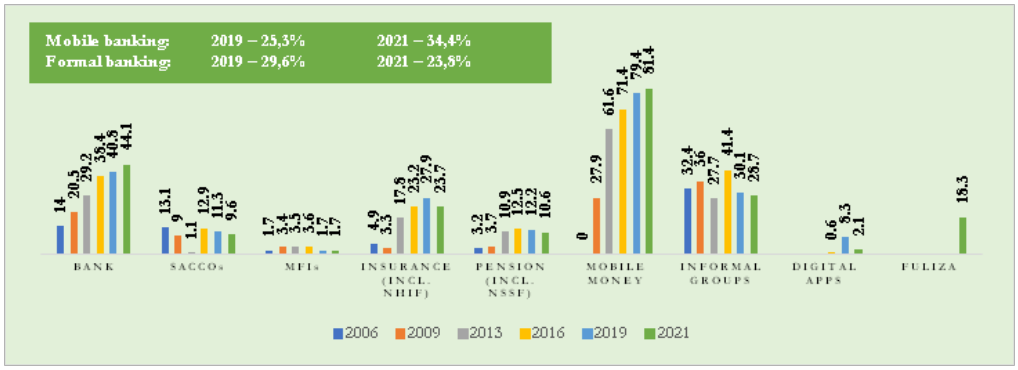
For a closer contextual analysis, we juxtaposed the change in the consumption of fintech services against the change in formal financial access. The data, plotted in Figure 3, show an increasing trend in digital finance uptake with mobile money usage, for example, having grown from 27.9% of the population in 2009 to 81.4% in 2021. Similarly, the usage of mobile banking, an important aspect of the fintech ecosystem, expanded from 25.3% in 2019 to 34.4% in 2021. Overall, growth in the consumption of fintech services appears to coincide with increasing access to and possibly usage of formal financial services during the same period. Thus, a close relationship potentially exists between dynamics in the usage of fintech ecosystem products and changes in financial inclusion in Kenya. Whether this apparent nexus is indicative of an unequivocal role that the fintech ecosystem plays in influencing usage of formal financial products is an empirical question, which we explored as a major objective of this paper.

Figure 2: Access to financial services by location of residence, 2006–2021



Source: FinAccess Kenya Household Survey, 2021

Figure 3: The changing landscape of financial services in Kenya, 2006–2021



Source: FinAccess Kenya Household Survey, 2021

4. Data, measurement, and descriptive analysis

Variables and measurements

Financial inclusion

As discussed, we used the term financial inclusion to refer to the consumption of formal (intermediated) financial products of regulated financial institutions and capital markets. Thus, we proxied financial inclusion with savings, credit and insurance (for financial institutions usage) and investments (for capital markets usage). We omitted pensions usage because enrolment into pension and provident funds is strictly governed by regulation such that pension usage may sometimes reflect statutory obligations on the part of employers rather than individual choices. We defined usage as "currently using" a financial product[15].

Engagement with the fintech ecosystem

According to Arner et al. (2020), the fintech ecosystem rests on a digital financial infrastructure comprising four pillars: (i) digital ID and electronic know-your-customers; (ii) open electronic payment systems, infrastructure and an enabling regulatory and policy environment; (iii) account opening initiatives and electronic provision of government services; and (iv) digital financial market infrastructure and systems that support value-added financial services and deepen access, usage and stability. The infrastructure serves five broad categories of actors in the fintech space (Lee and Shin, 2018). On the supply side are fintech firms (which offer technology-linked payments, financing, wealth management and other services); technology developers (offering services such as big data analytics, cryptocurrency and cloud computing); and traditional financial institutions (e.g., banks, insurance firms and mutual funds). On the demand side, comprising largely non-traditional interdependencies founded upon data generated by product usage, are consumers of financial services and products. The fifth actor is the government through its financial sector regulatory agencies.

The generic identification of actors (Lee and Shin, 2018) and their interconnectedness in an African-country context (Senyo et al., 2022) is the first step toward understanding

the fintech ecosystem. More important, in the context of this study, is to appreciate the modalities of action of these actors in the financial inclusion realm. In their framework, Kangwa et al. (2020) proposed a set of conditions necessary for the fintech ecosystem to facilitate financial inclusion. On the demand side are digital consumerism (characterized by ownership of digital devices, social media networking, and ability and propensity to use digital technologies), financial capability (possession of functional knowledge of financial products, as well as behaviour and attitude that can facilitate the consumption of digital financial products); and financial literacy (possession of skills and knowledge that enable an individual to make informed financial choices). The supply side conditions include availability and accessibility of financial products, regulatory frameworks and financial technology. This set of conditions establishes the "building blocks" for a metric that describes "engagement with the fintech ecosystem", which we labelled the fintech ecosystem at the micro-level.

Accordingly, digital consumerism, which represents fintech start-ups and technology developers in the fintech ecosystem, and the supply of and demand for technology, is proxied by responses to the following questions in the survey instrument: (i) currently registered on a mobile money platform; (ii) owns a mobile phone or has access to someone else's mobile phone; (iii) mobile phone can access the Internet; (iv) member of the household owns fixed Internet at home (e.g., Fibre, Satellite dish, LAN and Wi-Fi); and (v) currently registered to use mobile money. Financial capability, which represents functional knowledge of fintech products by consumers (demand-side) is proxied by transaction usage of digital money services, namely (i) paid monthly bills using a mobile money account; (ii) paid monthly bills using pay bill/till number using mobile money; (iii) paid school fees using a mobile money account; (iv) paid school fees using pay bill/till number using mobile money; (v) paid daily expenses using a mobile money account; (vi) paid daily expenses using pay bill/till number using mobile money; (vii) sent/gave money inside Kenya using a mobile money account; (viii) sent/gave money inside Kenya using pay bill/till number using mobile money; (ix) received money from inside Kenya using a mobile money account; (x) received money from inside Kenya using pay bill/till number using mobile money; (xi) paid a bill for medical treatment using a mobile money account; and (xii) paid a bill for medical treatment using pay bill/till number using mobile money. We were careful not to include in this list any applications that were directly linked to formal financial institutions such as M-Shwari and virtual banking, since individuals using them are (already) financially included.

Financial literacy was proxied by responses to the question: "Suppose you take a loan of KES 10,000 with an interest rate of 10% per year, how much more money do you have to pay at the end of the year?" To capture consumers' experiences with the quality of provisioning of fintech services (which also speak to fintech firms on the supply side of the fintech ecosystem), we followed the activity system theory (Karanasios, 2018), according to which harmony in an ecosystem may be compromised by contradictions, which manifest in the form of breakdowns, disputes and conflicts

within and between sources of activity in the ecosystem. Sources of activity in the fintech ecosystem include people, organizations, technologies and practices (Malaurent and Karanasios, 2020). Thus, we represented disharmony in the fintech ecosystems (as experienced by consumers/users) by information from the following FinAccess issues: (i) mobile money account inability to transact due to system down time; (ii) mobile money account agent float unavailability; (iii) mobile money account holder unable to get to an agent; and (iv) mobile money account fraud/attempted fraud (e.g., received less money from agent). These issues constitute a "dysfunction" in the provision of digital financial services, with the potential to adversely affect consumer utility and are, accordingly, penalized in the fintech ecosystem construct with a negative sign[16]. We took the existence of some supply side factors, such as regulatory quality, as given (Kenya, as mentioned, has an advanced digital finance subsector with a well-developed and functional regulatory framework).

Engagement with the fintech ecosystem was constructed as a score that increases by one for every relevant question on the demand side to which the respondent answers "Yes" and reduces by one (due to the negative sign) for every question on the supply side to which the respondent answers "Yes". For the robustness check, we also constructed a fintech ecosystem index and a more simplified fintech dummy. The results of tests with these alternative constructs are discussed in Section 5.4.3.

Control variables

The control variables were gender and location of residence, given that studies in many countries have found women and rural inhabitants to bear a disproportionate burden of financial exclusion (Ghosh and Vinod, 2017; Johnen and Mußhoff, 2022) and are less likely to use fintech services (Ghosh, 2022). We also included age (in years) and age groups (in separate regressions), both of which studies have found to be not only important in influencing financial product usage (Allen et al, 2021), but also to act as a critical factor moderating the adoption of digital finance services (Liébana-Cabanillas et al., 2014). A preponderance of literature suggests that, possibly due to their quickness in adopting new developments in digital technologies, middle-aged individuals have a higher propensity to use fintech services than younger and more elderly individuals. That is, we expected age to have a non-linear relationship with the fintech ecosystem. For financial inclusion regressions, we expected the coefficients of age groups to be broadly positive relative to the 16–17-year age group, which served as the reference point.

On language, evidence showed that Kenyans who speak Kiswahili or English had a higher chance to be financially included than those who could not communicate in either of these two languages (Allen et al., 2021). However, this evidence may be circumstantial: Kenyans typically learn English at school and those who have not been to school learn Kiswahili on the streets in urban areas where it is the language for cross-cultural interaction. Thus, in general, given the confluence between language and both education and urban residence, both of which are known to have a positive

impact on financial inclusion (e.g., Liao et al., 2015), we expected the coefficients of both Kiswahili and English to be positive. Additionally, Liao et al (2015) provide evidence suggesting that the effect of education is a priori positive: education gives individuals better knowledge of financial products and improves their confidence in consuming technological innovations.

Other variables that are known to explain financial inclusion and use of fintech products, include income, which as mentioned, tends to positively affect financial inclusion (Demir et al., 2022); financial literacy, documented previously to have a positive relationship with financial inclusion in Kenya (Kodongo, 2018) and in a cross-section of countries with varied institutional quality (Grohmann et al., 2018). The study by Grohmann et al. (2018) is interesting given its finding that financial literacy reinforces the positive effect of financial depth on the use of financial services; and income type or occupation, whose effect depends on the nature of the individual's occupation: waged individuals for example tend to have higher levels of financial inclusion than those who are self-employed ("in business"), and farmers (Kodongo, 2018;). Studies (e.g., Allen et al., 2021) have also documented close correlation between asset ownership and financial inclusion. Thus, we incorporated asset ownership, constructed as a score that increases by one for every asset owned, in the estimated equation.

Summary statistics

Table 1: Variable construction and summary statistics

Variable	Construction	Mean	SD
Fintec ecosystem	Score of various variables as described in Section 3.2.2	4.517	2.671
Rural dwelling	Dummy equal to 1 if an individual lives in rural areas	0.679	0.467
Female	Dummy equal to 1 if individual is of female gender	0.566	0.496
Age	Actual (integer) age, in years, of individual	39.20	18.05
Age (18–24 years)	Dummy equal to 1 if age (years) is in the range [18, 24]	0.179	0.383
Age (25–34 years)	Dummy equal to 1 if age (years) is in the range [25, 34]	0.251	0.434
Age (35–44 years)	Dummy equal to 1 if age (years) is in the range [35, 44]	0.182	0.386
Age (45 – 54 years)	Dummy equal to 1 if age (years) is in the range [45, 54]	0.121	0.326
Age (over 55 years)	Dummy equal to 1 if age (years) is in the range [55, 64]	0.209	0.406
Language: English	Dummy equal to 1 if individual speaks English	0.323	0.467
Language: Kiswahili	Dummy equal to 1 if individual speaks Swahili	0.597	0.491
Education: Primary	Dummy equal to 1 if highest education is "primary"	0.409	0.492
Education: Secondary	Dummy equal to 1 if highest education is "secondary"	0.289	0.453
Education: Tertiary	Dummy equal to 1 if highest education is "technical"	0.108	0.310
Occupation: business	Dummy equal to 1 if individual is self-employed	0.002	0.044
Occupation: waged	Dummy equal to 1 if individual is wage-employed	0.113	0.317
Occupation: farming	Dummy equal to 1 if individual is a farmer	0.309	0.462

continued next page

Table 1 Continued

Variable	Construction	Mean	SD
Occupation: casual	Dummy equal to 1 if individual is in temporary employment	0.392	0.488
Asset ownership	Score of assets owned	1.295	1.222
Possession of ID	Dummy equal to 1 if individual owns an ID	0.879	0.326
Low income	Dummy equal to 1 if individual earns less than KES 30,000 pm	0.863	0.344
Middle income	Dummy equal to 1 if individual earns KES 30,001–200,000 pm	0.023	0.150
North Kenya	Dummy equal to 1 if individual is drawn from Northern Kenya	0.131	0.337
Disability	Dummy equal to 1 if individual has at least one disability	0.145	0.352
Touchscreen	Dummy equal to 1 if the respondent owns a touchscreen phone	0.263	0.440
Internet use	Dummy equal to 1 if one uses internet more frequently than annually	0.293	0.455
No. of observations		7,230	

Descriptive statistics are shown in Table 1. The mean value of the fintech ecosystem proxy was 4.517 during 2021, out of a plausible maximum[17] of 18 with a standard deviation of 2.671, indicating that about 68% of the polled individuals scored between (approximately) 2 and 7, which are below the conceptual midpoint of 9. Thus, despite the reported growth in the consumption of fintech services (Figure 1), the average Kenyan is not yet adequately integrated into the fintech ecosystem. Women and rural dwellers constituted about 56% of the sampled individuals; the average respondent was 39 years old; and the bulk (43%) of the respondents were youthful, i.e., aged 18–34 years (the 16–17-year age group served as the reference group).

Most of those sampled (about 60%) spoke Kiswahili, only a small proportion of the respondents (about 11%) had attained or been exposed to some tertiary (university or technical) education while a large proportion of the respondents were either casual labourers (39%) or engaged in farming (31%) (Table 1). Asset ownership reported an average of 1.30 relative to a plausible maximum of 10, potentially indicating low levels of welfare in the population. The proportion of the low-income population was fairly high at over 85% of the population, consistent with the inference of low levels of welfare made when using asset ownership. Finally, because northern Kenya had by far the least developed infrastructure in Kenya, we included a dummy that takes the value of 1 if a respondent was drawn from there and 0 otherwise: about 13% of respondents resided in the sparsely populated and semi-arid northern Kenya region.

5. Empirical analysis

Explaining the usage of fintech products

We began by attempting to ascertain the possible reasons for individual engagement with the fintech ecosystem in Kenya. We tested the hypotheses that individual propensity to use fintech platforms was shaped by constraints that they faced in accessing physical branches of financial institutions; their consumption of financial products (e.g., credit, insurance) was subject to constraints such as distance to financial institutions (hypothesis H1); information asymmetry arising from their lack of or inadequate financial transactions history (H2); and availability of suitable financial products (H3). That is, we conjectured that individuals used the fintech ecosystem as a medium that enables them to overcome barriers to formal financial inclusion that they face. To test these hypotheses, we estimated Equation 1 using Poisson regression:

$$\ln \lambda_i = \delta_0 + \delta_1 His_i + \delta_2 Dis_i + \delta_3 Aprd_i + \delta_4 NKen_i + \theta' Controls_i + \varepsilon_i \quad (1)$$

where λ is the expected value of the fintech ecosystem score.[18] The explanatory variables were proxies for "having a history of financial transactions" (*His*), "appropriateness of product offerings of financial institutions" (*Aprd*) and "distance to a financial institution" (*Dis*). The variables were constructed from the following reasons given by respondents for not having a bank account: *His* = "I have to keep a minimum balance at the bank"; *Dis* is proxied by the cost of public transport to the nearest bank being at least KES 200; and *Aprd* = "I prefer to use other options rather than the bank". We added a dummy variable (*NKen*) that equals "1" if the respondent is from northern Kenya where the fintech infrastructure is relatively less developed, and "0" elsewhere, and Controls. δ_x (x = 1,2,3) should be positive and significant if fintech products were a substitute for traditional products of regulated financial institutions and markets, and significantly negative if fintech products complemented traditional financial products. Since the fintech subsector is relatively underdeveloped in northern Kenya, we expected δ_4 to be negative.

Table 2 reports results of the Poisson regression, with the ordered logistic (O-Logit) and ordinary least squares (OLS) estimations serving as robustness checks. Since the three techniques yield qualitatively similar results, we only discussed the Poisson results. The dependent variable, individual engagement with the fintech ecosystem, reported a negative (-1) score for 15 individuals (out of the 7,230 in the sample). To use the Poisson

regression, which takes the logarithm of the dependent variable, we dropped the 15 observations[19]. Column 1 reports results for the regression with only the three key explanatory variables included. Column 2 adds the northern Kenya dummy to the three variables, and we incorporated additional controls in columns 3, 4 and 5. We reported bootstrap standard errors (with seed arbitrarily set equal to 0.50 for replicability), clustered by the respondents' counties of residence consistent with standard practice in the literature (e.g., Allen et al., 2021). The findings suggest that residents of northern Kenya tend to be disadvantaged in using products available on the fintech ecosystem. Specifically, all else being equal, residents of the northern Kenya region used the fintech ecosystem between 0.77 times and 0.81 times less than residents of the other regions of the country[20].

Possession of an identification document (ID) was highly economically significant in informing engagement with the fintech ecosystem in Kenya, which possibly speaks to the fact that most individuals consume fintech products via mobile phones for which SIM card registration is conditional on meeting know-your-customer requirements. The results also showed (Column 3), consistent with existing studies on the digital divide (Grishchenko, 2020), that younger individuals were generally more likely to use fintech services than more elderly individuals with the usage peaking at some age (negative coefficient estimate for age squared) then diminishing and, expectedly, that higher income promotes usage of fintech ecosystem products. The coefficient estimates for lower income were insignificant and low in magnitude compared to those of middle income, implying that higher income benefits individuals more than they lose from lower income, which emphasizes the underlying importance of income in engagement with the fintech ecosystem. The results also showed that rural inhabitants and disabled individuals were generally more disadvantaged in access to and usage of fintech products (consistent with Bin et al., 2020).

Contrarily, "distance to financial institutions", proxied by cost of transport to the nearest bank, was negatively and significantly related to the utilization of the fintech ecosystem. Thus, contrary to expectations, informed by recent studies (Jack and Suri, 2014; Dupas et al., 2018), distance appeared to disincentivize the consumption of fintech products in much the same way that it discourages access to financial institutions. This is plausible. Take transaction usage of digital money services (e.g., cash withdrawals) for example: this necessarily entails the user interacting with digital money agents, who are typically found in local commercial centres. Similarly, use of mobile money in certain ways, such as for buying goods, often requires the individual to travel to the locations where the goods are sold (in local commercial centres) in order to use the till number of the seller and to collect the goods; this is akin to traveling to the bank to withdraw money in cash before shopping. Where the commercial centres referred to in these examples are the same locations in which agents/branches of financial institutions are situated, distance entails similar disincentives (e.g., travel costs and opportunity costs of foregone earnings) to the use of fintech services as it does to physical access to financial institutions[21].

The important implication of these findings is that the fintech ecosystem is a possible important alternative avenue (as a substitute to or compliment of conventional financial products) for promoting financial inclusion in Kenya. This possibility is examined in subsequent sections.

Table 2: Explaining usage of fintech products in Kenya

Estimation method	Poisson		Ordered logistic		OLS
	(1)	(2)	(3)	(4)	(5)
Distance to bank	-0.372 ***	-0.300 ***	-0.136 ***	-0.436 ***	-0.466 ***
	(0.047)	(0.044)	(0.035)	(0.101)	(0.119)
History of transactions	0.121 ***	0.112 **	0.083 ***	0.403 ***	0.325 **
	(0.044)	(0.050)	(0.028)	(0.142)	(0.149)
Product appropriateness	0.060	0.058	0.011	-0.003	-0.005
	(0.058)	(0.058)	(0.053)	(0.247)	(0.265)
Northern Kenya		-0.255 ***	-0.210 ***	-0.750 ***	-0.804 ***
		(0.056)	(0.053)	(0.221)	(0.185)
Owns ID			0.425 ***	1.550 ***	1.666 ***
			(0.025)	(0.083)	(0.086)
Age (years)			0.029 ***	0.099 ***	0.097 ***
			(0.002)	(0.009)	(0.009)
Age squared (×100)			-0.035 ***	-0.114 ***	-0.112 ***
			(0.003)	(0.009)	(0.009)
Low income			-0.007	-0.032	-0.024
			(0.010)	(0.049)	(0.046)
Middle income			0.097 ***	1.087 ***	1.096 ***
			(0.028)	(0.181)	(0.199)
Rural dwelling			-0.097 ***	-0.483 ***	-0.511 ***
			(0.019)	(0.085)	(0.096)
Disability			-0.074 ***	-0.287 ***	-0.327 ***
			(0.024)	(0.091)	(0.097)
Constant	1.560 ***	1.579 ***	0.412 ***		0.571 ***
	(0.024)	(0.024)	(0.056)		(0.212)
R-squared†	0.015	0.020	0.159	0.145	0.505
Wald χ^2 [p-value]	67	81	3873	5145	5756
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Log pseudo-likelihood	-17497	-17408	-14883	-14454	
No. of observations	7215	7215	7187	7187	7187

Note: This table reports estimation outputs for Equation 1 with robust standard errors, clustered by county of residence in the hypotheses; † Pseudo R-squared and adjusted R-squared were reported respectively for maximum likelihood and ordinary least squares (OLS) estimations; ID stands for identification document; *** = p<0.01, ** = p<0.05 and * = p<0.10

The fintech ecosystem and usage of formal financial products

Having established possible reasons for Kenyans to use the fintech ecosystem, we next explored the effect of fintech ecosystem engagement on the usage of formal financial products (i.e., we tested hypothesis H1). Our identification strategy was guided by the econometric specification in Equation 2, which facilitates the examination of engagement with the fintech ecosystem as a determinant of formal financial products usage.

$$Usepdt_i = \gamma_0 + \gamma_1 Finsys_i + \gamma_2' Controls_i + \varepsilon_i \quad (2)$$

where $Usepdt_i$ is the log of the odds ratio of the usages of financial products by the ith individual[22], proxied alternately by various metrics of non-transactional formal usages including credit, investments, savings and insurance. $Finsys_i$ is constructed as a fintech usage score for the i^{th} individual; and $Controls_i$ represents various characteristics of individuals believed, in the literature (see e.g., Kodongo, 2018; Allen et al., 2021), to be able to explain financial inclusion in Kenya and include age, level of education, rural dwelling, gender, asset ownership score, ability to speak Kiswahili or English, income type (occupation) among others. Equation 2 was estimated through logistic regression. For robustness checks, we later ran an instrument variable regression (Section 5.4.1) given the possibility of endogeneity because use of the fintech ecosystem or financial products may not be a random occurrence because of which the relationship between the two variables may reflect simultaneity bias. Kenyan counties exhibit a notable disparity in the aggregate income[23], which may also reflect in the extent of financial inclusion. To control this, we clustered standard errors by county (administrative unit). ε_i is the white noise with zero mean and variance $\sigma^2_{\varepsilon_i}$.

The results (marginal effects) for usage of various formal products of financial institutions (savings, credit and insurance) and financial markets (investment in securities such as stocks and bonds, and in investment companies such as unit trusts) are reported in Table 3. We began with the diagnostic tests reported at the bottom of the table. First, we checked the goodness of fit of the model using the Hosmer–Lemeshow (2013) test[24]. All four models reported high chi-square p-values exceeding the 10% conventional threshold: thus, we could not reject the hypothesis that the models tested were an appropriate fit. Next, we used the link test[25] to check the adequacy of the functional form specified for estimation, and whether all important explanatory variables were included in the tested specifications. The results showed significant hats and insignificant hats-squared, thus affirming the adequacy of the estimated functional forms.

Table 3: Explaining usage of financial products

Financial product	Institutions			Markets
	Savings	Credit	Insurance	Securities
Fintech ecosystem	0.016 ***	0.009 ***	0.027 ***	0.005 ***
	(0.002)	(0.001)	(0.003)	(0.002)
Female	-0.022 ***	-0.004	-0.017	-0.010 **
	(0.007)	(0.005)	(0.011)	(0.004)
Rural dwelling	0.008	0.013 *	-0.034 **	-0.004
	(0.010)	(0.007)	(0.014)	(0.005)
Age group (18–24)	0.130 *	0.550 ***	0.029	-0.009
	(0.070)	(0.054)	(0.031)	(0.018)
Age group (25–34)	0.210 ***	0.615 ***	0.110 ***	0.004
	(0.067)	(0.053)	(0.035)	(0.018)
Age group (35–44)	0.248 ***	0.652 ***	0.156 ***	0.025
	(0.069)	(0.056)	(0.034)	(0.019)
Age group (45–54)	0.255 ***	0.655 ***	0.181 ***	0.020
	(0.072)	(0.054)	(0.038)	(0.019)
Age group (55+)	0.277 ***	0.653 ***	0.266 ***	0.045
	(0.071)	(0.055)	(0.031)	(0.019)
Language: English	0.015	0.047 ***	0.033	0.021 *
	(0.031)	(0.016)	(0.035)	(0.013)
Language: Kiswahili	-0.001	0.035 ***	0.011	0.011
	(0.029)	(0.012)	(0.032)	(0.010)
Education: Primary	-0.013	-0.014 *	-0.036 **	-0.012 ***
	(0.011)	(0.008)	(0.015)	(0.004)
Education: Secondary	0.006	-0.011	-0.001	-0.002
	(0.010)	(0.007)	(0.015)	(0.005)
Education: Tertiary	0.012	-0.006	-0.002	-0.007
	(0.009)	(0.006)	(0.011)	(0.006)
Occupation: Farming	0.063 ***	0.027 ***	0.010	0.016 ***
	(0.012)	(0.007)	(0.015)	(0.005)
Occupation: Waged	0.119 ***	0.078 ***	0.200 ***	0.012 *
	(0.013)	(0.008)	(0.014)	(0.007)
Occupation: Business	0.080 *	0.081 ***	0.123 *	0.044 **
	(0.048)	(0.030)	(0.075)	(0.021)
Asset ownership	0.021 ***	0.012 ***	0.048 ***	0.010 ***
	(0.004)	(0.002)	(0.005)	(0.002)
Constant†	-7.312 ***	21.493	-4.244 ***	-6.975 ***
	(0.962)	(0.000)	(0.409)	(0.902)

continued next page

Table 3 Continued

Financial product	Institutions			Markets
	Savings	Credit	Insurance	Securities
p-value of Wald	0.000	0.000	0.000	0.000
Hosmer–Lemeshow	0.889	0.979	0.165	0.339
Hat	0.000	0.000	0.000	0.000
Hat squared	0.798	0.701	0.336	0.922
# Observations	7230	7230	7230	7230

Note: This table reports the marginal effects from the logistic regression with various usages of financial products of regulated financial institutions and markets as dependent variables; robust standard errors are clustered by county of residence; we computed standard errors for the marginal effects regression using the Delta method; † indicates that the reported value is from the original logistic regression (i.e., not marginal effect); # represents "number of"; *** = p<0.01, ** = p<0.05 and * = p<0.10

Focusing next on the results of the estimations, the findings suggest that engagement with the fintech ecosystem is strongly positively related to individual consumption of formal financial products. Specifically, engagement with the fintech ecosystem increases the probability of usage of formal financial products of regulated financial institutions by at least 0.9% after controlling for various individual-level factors and locational factors typically associated with access and usage of financial products. Expectedly, the fintech ecosystem had a weaker relationship (economic importance of the coefficient estimate was only 0.5%) with investments usage, whose products are still in their infancy, with usage appealing largely to sophisticated and wealthy investors who can access investment advice at a fee. Several other reasons can explain the finding on investments usage. First, securities investing is not yet popular among Kenyans, most of whom have only basic knowledge of the functioning of financial markets: the 2021 FinAccess Survey? data showed that only about 2.7% of Kenyans have or have had investments in the securities markets.

Second, except the M-Akiba bond that is offered to retail investors on digital platforms, the supply-side of the securities market relies heavily on traditional methods of securities issuances, with marketing efforts (usually via conventional outlets like investment banks) typically targeting sophisticated urban investors and institutions. Third, there has been a lull in initial public offerings (IPOs) of stocks since the mid-2000s and some oversubscribed IPOs of yesteryears have recorded weak long-term performance (e.g., the Kenya Electricity Generating Company (KenGen)) or been delisted (e.g., Access Kenya). While the dearth of IPOs has denied the stock market the necessary publicity that IPOs engender, the weak performance of previous IPOs has discouraged retail investors, some of whom employed leverage in their debut stock purchases, from participating in securities markets.

It is important to note that most of the control variables, when significant, recorded coefficient estimates with the expected signs. For example, individuals in business (self-employed) were more likely to use capital markets products while women were less likely to save in financial institutions and acquire assets in the financial asset markets consistent with findings of recent studies (e.g., Johnen and Mußhoff, 2022). Finally, we found, interestingly, that the probability of using formal financial products generally increased with age.

Mitigating financial inclusion barriers

Following the results in Section 5.2, which documents robust evidence that engagement with the fintech ecosystem affects financial inclusion, we explored the mechanisms of action of the fintech ecosystem as a financial inclusion enabler. We were guided by the special agent theory (Ozili, 2020), which argues that complex issues relating to the nature of the population, the characteristics of its people and geography may impede the provisioning of financial services to a section of the population. To address such barriers, specialized agents (e.g., fintech firms and technology firms) may be required to more effectively reach those who are financially excluded[26]. To be effective, the specialized agent(s) must be able to understand the peculiarities of the excluded (in the fintech ecosystem, this is often achieved through big data); devise ways to integrate the informal financial system into the formal financial system (e.g., through the use of formal digital savings products); and identify modalities of intervention (e.g., through product innovation). This section deals with the modalities of intervention (mechanisms of action).

Understanding the mechanisms of action is important for several reasons. First, it reduces the concern that the relation between engagement with the fintech ecosystems and financial inclusion may be spurious and perhaps driven by extraneous factors that may contemporaneously affect both. Second, it also informs our appreciation of how the fintech ecosystem works and generates insights for policy formulation. A well-functioning fintech ecosystem should promote financial inclusion by mitigating its impediments, which may be price or non-price related. Price-related barriers include inadequate or no income to maintain a financial institution account, cost of financial services (e.g., loan origination fees) and complicated products; non-price-related barriers include distance from financial institutions (e.g., Jack and Suri, 2014; Bachas et al., 2018), distrust of financial institutions, psychological fear of traditional financial institutions, financial literacy and poor knowledge of financial products[27]. For example, some studies have argued that the exclusion of individuals without history can be addressed by gaining better insights about them and reducing information asymmetry using appropriate fintech tools (Daniel and Grissen, 2015; Jagtiani and Lemieux, 2018).

We investigated whether the fintech ecosystem may indeed mitigate some of these barriers by examining its role in the possible attenuation of the major reasons, which unbanked individuals gave in response to the question of why they do not have a financial institution account. We implemented these "reasons" by interacting them with our individual engagement with the fintech ecosystem construct, consistent with the implications of the special agent theory. That is, we re-estimated Equation 2 with engagement with the fintech ecosystem moderating the barriers' effects on financial inclusion, using logistic regression. Incorporating the usual controls, we estimated the resulting Equation 3:

$$Usepdt_i = \gamma_0 + \gamma_1 Finsys_i + \gamma_2' Chan_i + \gamma_3' Finsys_i \times Chan_i + \Gamma' Controls_i + \varepsilon_i \quad (3)$$

where *Chan* are respondents' reasons for not using formal financial products such as distance from the bank, which Osoro and Muriithi (2018) found to be directly associated with usage of banking services in Kenya; history of transactions; and

appropriateness of financial products. The results, displayed in Table 4, showed that the fintech ecosystem remains strongly positively related to formal financial product usage. Distance is a dummy variable equal to "1" for individuals who answer, "KES 200 or more" to the question "If you had to go to any nearest bank branch, ATM or headquarters, what is the average cost to go there by public transport (one way)?" and "0" elsewhere. As expected, the results indicated that "distance" was negatively and strongly significantly related to effective financial inclusion in Kenya. Living at least KES 200 away from a bank lowered the probability of usage of products of financial institutions by 17%, 7% and 9% respectively for savings, credit and insurance usages; it lowers the consumption of investment products by about 4%.

As argued, the fintech ecosystem should help mitigate the constraints to financial product consumption imposed on individuals by distance (Dupas et al., 2018) so that the interaction between "fintech ecosystem" and "distance" should be positive. The results supported the positive "distance effect" hypothesis, particularly for savings, credit, and insurance for which fintech usage "reverses" the distance disadvantage by at least 1 percentage point. Thus, we inferred that the fintech ecosystem attenuates the distance barrier and hence complements efforts by traditional financial institutions and regulatory authorities to encourage usage of intermediated financial products and services. Where the effect appeared lower than 1% as is the case with investments, it is plausible that some financial needs are addressed directly by fintech (as a substitute to traditional financial products). For example, by introducing innovative products such as *M-Akiba*, the Central Bank of Kenya encourages online investing, which competes with traditional broker-driven services.

The "history" dummy as defined, equals "1" when an individual answers "I have to keep a minimum balance at the bank" to the question "Why don't you have your own bank account?". We interpreted this response to mean that the individual's lack of a "minimum balance" implied that they cannot show a record of financial institution usage (history) which may make them ineligible for products such as credit whose scoring systems emphasize history of financial transactions as an indicator of "willingness to pay". As expected, "history" had a negative effect on financial inclusion and was significant for both savings and investments usages. The coefficients of the interaction term were, however, mixed: negative for some uses (e.g., insurance) and positive for others (e.g., investments). When significant, the fintech ecosystem either attenuates (e.g., investments) or accentuates (e.g., insurance) the discriminating effect of history on traditional financial product usage. Despite empirical evidence suggesting weak demand for micro-insurance (Platteau et al., 2017), many insurance firms in Kenya have recently adopted a digital micro-insurance strategy that targets low-income populations, a development with the potential to build micro-insurance as a distinct tech-driven market segment competing with traditional insurance products.

Table 4: Channels through which fintech ecosystems work

	Savings			Credit			Insurance			Investments		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Fintech score	0.01***	0.02***	0.02***	0.01***	0.01***	0.01***	0.03***	0.03***	0.03***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Distance	-0.17***			-0.07**			-0.09***			-0.04**		
	(0.05)			(0.02)			(0.03)			(0.02)		
History		-0.17*			-0.10			0.06			-0.66***	
		(0.10)			(0.09)			(0.08)			(0.09)	
Product app.			0.14***			0.04*			0.05			-0.02
			(0.04)			(0.03)			(0.06)			(0.02)
Fintec×Dist	0.02**			0.01**			0.01**			0.00*		
	(0.01)			(0.00)			(0.00)			(0.00)		
Fintec×Hist		0.02			0.01			-0.02*			0.64***	
		(0.01)			(0.01)			(0.01)			(0.09)	
Fintec×PA			-0.02**			-0.01*			-0.01			0.01**
			(0.01)			(0.00)			(0.01)			(0.00)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
p-values of												
Wald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HL	0.313	0.289	0.454	0.162	0.201	0.455	0.199	0.091	0.071	0.538	0.279	0.210
Hat	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hat-sq.	0.916	0.741	0.754	0.377	0.627	0.859	0.101	0.257	0.285	0.763	0.891	0.999
# Obs.	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230

Note: Dist is distance to the nearest bank; Hist is history of financial transactions; and PA is product appropriateness; "app" stands for appropriateness; HL is an abbreviation for the Hosmer–Lemeshow test; *** p<0.01, ** = p<0.05 and* = p<0.10.

As defined, product appropriateness is proxied by respondents' answers to the question of why they do not currently use banking services: "I prefer to use other options rather than the bank". Individuals with this "attitude" tend to prefer alternative, usually informal, financial service providers such as table banking (chamas) or registered, but non-prudential, formal financial service providers such as savings and credit cooperative societies (saccos). However, since such individuals are not necessarily averse to or unable to afford using the services or products of regulated financial institutions (e.g., microfinance institutions and banks), this variable on its own is also positively related to consumption of products of regulated financial institutions just as they would to similar service offerings of alternative institutions. Interacting it with the fintech ecosystem yielded a (generally) negative result, suggesting that in the presence of digital financial services, individuals with this attitude would prefer fintech products to physical branches of financial institutions (or their appendages such as agents and ATMs). Thus, the fintech options are a substitute to traditional financial services where product appropriateness (convenience of delivery and use) is concerned.

Additional tests and robustness

Addressing endogeneity concerns

Given that individual decisions to use fintech services do not occur randomly, there is the possibility that the same factors driving financial inclusion may drive fintech ecosystem usage, causing simultaneity (endogeneity) biases in our tests. Thus, in order to deal with the potential endogeneity, we re-estimated the probabilities of using traditional financial products through the instrument variable (IV) linear probability model (LPM) technique. But first, we addressed the question of whether IV-regression was really necessary. The bottom part of Table 5 reports results of some diagnostic tests. The test for exogeneity rejects the hypothesis that the estimated specifications (except for "investments") do not suffer from potential endogeneity problems. Thus, the results confirmed the need for treating the fintech ecosystem as endogenous to the consumption of formal financial products, justifying the IV-LPM regression[28].

Next, we attempted to address the more difficult issue of identifying appropriate instruments for our tests. The instrument variables for the fintech ecosystem engagement are "ownership of a touchscreen phone" and "regularity of Internet use". The identification assumption was that these two variables only affect use of formal financial products through their impact on fintech ecosystem use. It is plausible that the regularity of Internet use and ownership of a touchscreen phone are important for ease of fintech service use (participation in the fintech ecosystem) but are not directly linked to the probability that an individual may use products of regulated financial institutions. It is straightforward to appreciate the fact that when Kenyans, for example, use Internet services or use touchscreen phones, it is unlikely that their

main purpose is to stimulate the consumption of formal financial products[29]. Similarly, service providers and vendors are unlikely to supply Internet and sell touchscreen phones to promote the use of formal financial services among Kenyans. Therefore, if regular use of the Internet or ownership of a touchscreen phone is associated with reduced or increased consumption of formal financial products, it must be through the consumption of fintech products, some of which are closely linked to Internet use[30].

Thus, the two variables appeared to satisfy the fundamental restrictions, namely that they be correlated with fintech ecosystem usage (which they instrument) but have no known direct effect on the usage of traditional financial products, and hence, qualify as valid instruments for our tests. Additionally, we provided results of relevant supportive diagnostic tests. First, Hansen's J-statistics results show that the hypothesis of instrument appropriateness cannot be rejected. Second, the first stage regression outputs indicate that the instruments have strong explanatory power on the endogenous variable and are therefore appropriate for the exercise. Finally, the F-tests for excluded instruments refute the conjecture that the included instruments are weak and indicate that they are correlated with the endogenous variable, after considering the effects of other exogenous variables. The "regularity of Internet use" was constructed as a dummy variable equal to 1 if an individual uses Internet more often than annually, and 0 elsewhere. "Ownership of a touchscreen phone" is a dummy variable equal to 1 for individuals who own, and 0 for those who do not own, such phones.

The results of the IV-LPM regressions confirmed that the probability of use of traditional financial products is improved (by between 0.8% and 4%) for individuals who engage with the fintech ecosystem. Indeed, the results, whose bootstrapped standard errors were robust to county-level clustering, showed that the probabilities of using these financial products induced by the fintech ecosystem increase by a slightly higher magnitude when we addressed endogeneity (Table 5), than when we did not (Table 3). Thus, empirical tests that do not address endogeneity may underestimate, by a small margin, the true effect of the fintech ecosystem on the consumption of traditional financial products. Importantly, the smallness of the difference in effects, when we control endogeneity and when we do not, is further confirmation of the robustness of the results presented in Table 3.

Table 5: Instrument variable linear probability model outputs

Regression	First stage		Second stage							
Dependent variable	**Fintech**		**Savings**		**Credit**		**Insurance**		**Investments**	
No. of instruments	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**
Fintech			0.040 ***	0.039***	0.027 ***	0.026 ***	0.071 ***	0.069 ***	0.009 ***	0.008 ***
			(0.004)	(0.005)	(0.004)	(0.004)	(0.006)	(0.005)	(0.002)	(0.002)
Touchscreen	1.598 ***	0.533 ***								
	(0.125)	(0.037)								
Internet use	0.943 ***									
	(0.183)									
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Excl. instr. F-test	301	310								
RMSE	2.003	2.017								
Adj. R-squared	0.438	0.430	0.108	0.109	0.086	0.091	0.161	0.165	0.060	0.061
Exog. test p-value			0.000	0.000	0.000	0.000	0.000	0.000	0.130	0.363
Hansen test p-value			0.632		0.312		0.213		0.335	
# Obs.	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230

Note: This table reports results of the GMM estimation of the linear probability model for usage of financial products; bootstrapped standard errors, computed with 50 replications and seed = 0.15 are robust to county-level clustering; the instruments used are ownership of touchscreen phone and regularity of Internet use for the two-instrument regression and ownership of the touchscreen phone for the one-instrument regression; “Exog.” represents exogeneity; “Excl. instr. F-test” is the F-test for excluded instruments and RMSE is the root mean squared error; for regressions with one instrument, the equations are exactly identified, hence the J-statistic is not computed; *** = p<0.01, * =, p<0.05 and * = p<0.1

Financial inclusion beneficiaries of the fintech ecosystem

Given the mixed bag of social and demographic characteristics exhibited by potential consumers of financial products, it is important to ask which of these characteristics most effectively lend themselves to the mediating role of the fintech ecosystem in fostering financial inclusion. To respond to this question, we estimated a form of Equation 2 that includes the interaction between the fintech ecosystem, and the characteristics deemed to describe individuals most likely to participate in the fintech ecosystem (Gulamhuseinwala et al., 2015; Das and Das, 2020), namely (i) males; (ii) secondary or tertiary education; (iii) age group 18–34 years; and (iv) upper income class. A positive and significant interaction effect indicates that the fintech ecosystem has benefitted individuals of the characteristics represented by 1; a negative and significant effect shows that the profiles denoted by 0 represent the key beneficiaries.

We estimated Equation 4:

$$Usepdt_{it} = \gamma_0 + \gamma_1 Finsys_{it} + \gamma_3^{'} Demtic_{ijt} + \gamma_4^{'} Finsys_{it} \times Demtic_{ijt} + \Gamma^{'} Controls_{it} + \varepsilon_{it} \quad (4)$$

where *Demtic* is the demographic characteristic of interest for our tests. Results, presented in Table 6, show that the effect of the fintech ecosystem on the savings appetites of Kenyans of all the demographics examined was mute. The effect of the fintech ecosystem on the usage of the remaining financial products were mixed (significant for some user groups and insignificant for others). Focusing next on the key purpose of this section, the potential beneficiaries of the fintech ecosystem, the findings were interesting.

First, when important, the fintech ecosystem appeared to foster greater usage of formal financial products amongst "older adults" since the coefficient for "youth" (individuals aged 18–34 years) was negative and statistically significant for credit and investments. Thus, despite their relatively superior capabilities in adopting technological innovations (Kangwa et al., 2020), the fintech ecosystem does not appear to have adequately empowered younger individuals, who are traditionally marginalized in financial inclusion (Allen et al., 2016), to enjoy greater consumption of formal financial products. An interesting plausible alternative interpretation of this finding is in the context of the role of the fintech ecosystem in attenuating the financial inclusion gap occasioned by the digital divide (Grishchenko, 2020) between younger adults (generally deemed as more technology savvy) and older adults (deemed more technology shy). That is, benefits such as remote access to one's bank account that the fintech ecosystem avails may incentivize older individuals not only to adopt digital technologies but, importantly, to utilize them for financial services.

Second, our results show that, when significant (such as for insurance use), engagement with the fintech ecosystem appears to have unduly benefitted the richer segments of the Kenyan society (middle and higher income) more than it did the poor (low income), consistent with the argument of Natile (2020) that despite fintech's ability to accelerate financial access, it does not address the underlying vulnerabilities that are responsible for financial exclusion.

Table 6: Beneficiaries of the fintech ecosystems

	Savings				Credit				Insurance				Investments			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	12)	(13)	(14)	(15)	(16)
Fintech score	0.02***	0.02***	0.02***	0.02***	0.01***	0.01***	0.01***	0.01***	0.03***	0.03***	0.03***	0.03***	0.01***	0.01***	0.01***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fintec × Male	0.00				0.00				-0.00				-0.00**			
	(0.00)				(0.00)				(0.00)				(0.00)			
Fintec × Youth		0.00				-0.01***				-0.01				-0.00*		
		(0.00)				(0.00)				(0.00)				(0.00)		
Fintec × UpInc			0.01				0.00				0.03***				0.00	
			(0.00)				(0.00)				(0.01)				(0.00)	
Fintec × HigEd				0.00				-0.00				-0.01*				-0.00
				(0.00)				(0.00)				(0.00)				(0.00)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
p-values of																
Wald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HL	0.661	0.556	0.400	0.560	0.046	0.844	0.081	0.578	0.241	0.117	0.129	0.223	0.599	0..451	0.259	0.186
Hat	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hat-sq.	0.776	0.813	0.705	0.796	0.728	0.643	0.822	0.760	0.389	0.400	0.575	0.197	0.913	0.513	0.859	0.873
# Obs.	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230	7230

Note: This table reports marginal effects from logistic estimation of Equation 4; *Youth* = age group 18–34 years; *UpInc* represents upper income groups (middle and high); *HigEd* is higher education (secondary and tertiary); *** = p<0.01, **, = p<0.05 and * = p<0.10

Finally, the fintech ecosystem appeared to bridge the gender divide in the use of financial products: the coefficient of the interaction between men and the fintech ecosystem was negative and weakly significant (at 10%) for investments. Thus, the findings indicate that the fintech ecosystem usage improves the uptake of capital markets investments, interestingly, for women and older adults (people aged at least 35 years). Thus, the fintech ecosystem appears to have played the role of aiding traditionally disfavoured population segments to enjoy formal financial services in ways that are potentially welfare enhancing, especially given the consumption smoothing role of capital markets instruments.

Alternative construction of engagement with the fintech ecosystem

To check for the robustness of engagement with the fintech ecosystem construct, we used two alternative constructs. First, we formulated a synthetic index using standard deviation weights for each individual, i, in the sample: $w_i = (1/\sigma_i)/\left(1/\sum_i \sigma_i\right)$. In the second instance, we defined the fintech ecosystem in a way that distinguishes individuals who make higher (intense) use versus those who make lower (less intense) use of the fintech ecosystems: a dummy variable taking the value of 1 if engagement with the fintech ecosystem score equals or exceeds the 30th percentile (as a benchmark for higher usage informed by the strongly right skewed nature of the distribution of this variable), and 0 elsewhere. We then estimated Equation 2 using logistic regression technique with the same features as in the baseline tests. The results (see Table 7) were qualitatively similar to those reported in Table 3; they continued to document an unambiguous role for the fintech ecosystem in explaining the various forms of formal financial product usage.

Table 7: Alternative constructions of the fintech ecosystem

	Savings		**Credit**		**Insurance**		**Investments**	
Fintec index	0.003***		0.002***		0.005***		0.001***	
	(0.000)		(0.000)		(0.001)		(0.000)	
Fintec dummy		0.061*** (0.013)		0.048*** (0.010)		0.114*** (0.016)		0.021** (0.14)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
p-value of								
Wald	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HL	0.356	0.880	0.603	0.816	0.135	0.561	0.694	0.118
Hat	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hat squared	0.607	0.681	0.479	0.315	0.432	0.229	0.802	0.985
# Obs.	7230	7230	7230	7230	7230	7230	7230	7230

Note: This table reports results (marginal effects) of the logistic estimation of Equation 2, using alternative constructions of the fintech ecosystem at the microlevel—a dummy equal to 1 if an individual's fintech ecosystem score equals or exceeds the 30th percentile and an index constructed using standard deviation weights; HL represents the Hosmer–Lemeshow test; *** = 0.01, ** = p,0.05 and * = p<0.10

6. Conclusions and policy implications

Kenya has a reputation as a leader of fintech in Africa, with high growth in mobile money transactions in recent years. Data from the Central Bank of Kenya show that mobile money transactions increased by 17.5% from KES 3.26 trillion (USD 21.12 billion) to KES 3.8 trillion (USD 31.6 billion) in the first half of 2022. This represents about 32% of the country's GDP, estimated at KES 12 trillion (USD 99.8 billion) in 2022 money. Similarly, the country has made big strides in financial inclusion with access to services such as credit growing from about 66.4% of the population in 2016 to about 74.0% in 2021 and savings rising from about 34.2% to 60.8% during the same period. These developments make it likely that the expansion of the fintech ecosystem and usage of fintech services have played a role in the growth in financial inclusion. We examined this question and documented several interesting findings.

First, we demonstrated empirically that by facilitating reach beyond traditional markets, the fintech ecosystem mitigates the important distance barrier to financial inclusion. We also ascertained that in the presence of digital financial services, individuals would prefer them (fintech products) to similar products available only at physical branches of financial institutions (or their appendages such as agents and ATMs); thus, the fintech ecosystem is a substitute to traditional financial service providers such as banks and insurance companies that fail to digitalize their products.

Second, we document a robust positive relationship between the use of formal products of regulated financial institutions and markets and the fintech ecosystem. The fintech ecosystem increased the probability of usage of these products by at least 0.8% after controlling for various socio-demographic factors, locational bottlenecks (e.g., rural residence) and potential endogeneity. Third, we found that the benefits of the fintech ecosystem are not uniform across all user categories. For example, the uptake of securities' investments improved, interestingly, for women and older adults during 2021 but fell for men and younger adults, the latter being undesirable given the traditional marginalization of younger adults.

Several policy implications can be drawn from these findings. First, "investments" does not appear to respond with as high economic importance to the fintech "intervention" as do the other uses of financial products. This could possibly reflect low levels of awareness of opportunities available in the capital market which can be addressed from a policy perspective through education. Although the Central Bank of Kenya has over the years sponsored or directly participated in efforts to provide

financial education to Kenyans, these efforts could be intensified to rope more individuals into the ranks of the financially literate. Alternatively, the finding could indicate low levels of income in the country which may, for example, bar individuals from setting aside a minimum required amount to open a bank account. In this case, policy interventions would revolve around a multitude of fiscal policy actions capable of improving disposable incomes, such as greater tax reliefs, cash transfers or expansion of individual income tax brackets.

Second, targeted interventions may be required to make financial inclusion attractive to the marginalized populations (e.g., women, low-income individuals and women in rural areas). This should be in response to the finding here that, in the case of insurance, for example, the fintech ecosystem has largely benefitted the traditionally favoured upper income echelons of the Kenyan populace, which already disproportionately enjoy these services. Further, given the finding that residents of northern Kenya have a reduced chance of at least 21% of utilizing the fintech ecosystem, and given the important role that fintech appears to play in promoting financial inclusion, improved provisioning of physical infrastructure in the region is necessary.

Notes

1. In this paper, we have used the term, “traditional financial products” to refer to usage of formal financial products and services of regulated financial institutions and markets even if the formal products/services are offered on non-conventional platforms (mobile or Internet), and even if the institution has partnered with a non-regulated institution for broader reach. The word “conventional” is used to refer to services and products offered only on traditional platforms such as physical branches of financial institutions or brokerage houses. Further, in many parts of our discussion, we have used the short-form, “fintech ecosystem” to refer to “individual engagement with the fintech ecosystem”. We have used use the terms, “financial services” and “financial products” interchangeably.

2. For example, Kenya’s leading mobile service provider, Safaricom’s short-term credit service, *Fuliza*, charges a minimum maintenance fee of KES 18 per day on transactions between KES 1001 and 1500, which translates to a 36% monthly interest rate (accessed 03.10.2022?).

3. Critics such as Natile (2020) have argued that mobile money (specifically M-Pesa), although touted as a development agent, focuses on private profit and fails to address the underlying causes of financial exclusion such as lack of resources and irregular or low income. Also critical are the findings of Yue et al. (2022), who pointed out that fintech (typified by digital finance) has created perverse incentives, such as impulsive spending, whose consequence has been an increased debt burden among the newly included financial consumers, which has tended to overshadow the positive benefits of improved access to the credit market. Other critiques such as Gabor and Brooks (2017) aver that fintech thrives on commodification of new financial consumers’ personal data and use of data analytics to shape? individual behaviour in the direction that promises the largest pecuniary rewards to service providers at the expense of the consumers.

4. Financial institutions such as unit trusts and mutual funds routinely generate a risk profile of their investors, which they use to advise them (investors) on the most appropriate product portfolios and investment horizons.

5. This is according to a recent discussion paper by the Boston Consulting Group.

6. The sampling frame consisted of 5,360 clusters, stratified into urban and rural areas. The survey drew 11 households per cluster, from which 1 eligible individual, aged at least

16 years, was selected using the KISH grid. A total of 8,669 households participated in the survey.

7. To illustrate this point, Safaricom (a mobile service provider in Kenya) partnered with Commercial Bank of Africa (now NCBA) in 2012 to operate *M-Shwari*, a digital product that enables individuals to save and apply for credit in small denominations via their mobile money accounts. In the context of this study, *M-Shwari* can be seen as enabling previously financially excluded individuals to transit from "mere" access to digital payment and remittance services offered on their mobile money accounts to using formal financial services of a regulated financial institution. Details of the product are available on the Safaricom website.

8. In the 2021 Economic Survey, the Kenya National Bureau of Statistics has documented that Kenya's informal sector created 14.5 million jobs, accounting for 83.4% of total employment outside of small-scale agriculture. Further, the total number of self-employed and unpaid family workers in the modern sector was 156,100.

9. Other than transaction costs, informal sector players are often excluded from the formal financial system for reasons such as information asymmetry (especially moral hazard in credit contracts, which causes financial institutions to charge high default premiums) and lack of documentation (e.g., identification documents and/or asset ownership documents for potential collateral).

10. For Kenya, a transcript of mobile money transactions can be obtained from service providers by credit reference bureaus, and can, thus be used, where needed, to understand the historical "financial behaviour" of a credit applicant.

11. This is according to GSMA (2021) State of the Industry Report on Mobile Money.

12. The data are from Central Bank of Kenya's National Payments System database. Compare the value of Kenya's 2021 mobile money transactions (KES 6868.77 billion, or USD 62.44 billion using the average exchange rate for the year) to Sub-Saharan Africa's (USD 697.7 billion, the latest data available from the 2022 GSMA report) shows that Kenya's mobile money transactions constituted about 9% of all of Sub-Saharan Africa's mobile money transactions.

13. https://tracxn.com/explore/FinTech-Startups-in-Kenya

14. The data are from Central Bank of Kenya's Banking Sector Innovation Survey 2021.

15. The other options available in the FinAccess questionnaire are "used to use" and "never used". The questionnaire includes follow-up questions for individuals who "used to use" a product to explain why they no longer use the product, but the responses are too few-and-far-between to be useful for the current analyses.

16. The questionnaire has follow-up questions on the negative experiences, including whether the respondent attempted to resolve the issue and if the service provider addressed their concern. However, the responses are too few to be used meaningfully in constructing the fintech ecosystem usage score.

17. The *observed* minimum and maximum scores were 14 and -1 (not reported in Table 1).

18. The Poisson distribution is of the form: $P(Y = y_i) = \left(e^{\lambda_i} \times \lambda_i^{y_i}\right)/y_i!$. We modelled the expected (mean) count of fintech ecosystem engagement, λ_i, as a function of the explanatory and control variables.

19. Although 15 observations out of 7,230 is negligible, this practice may raise issues of possible survivorship bias in our tests. For robustness checks, we added one to every individual's score to meet the zero or positive value required for taking logarithms. The results, available upon request from the author, were essentially similar.

20. These are obtained respectively as exp(-0.255) and *exp*(-0.210). Alternatively, the (difference in the logs of) expected number of times of consumption of fintech products are lower by between 21% and 25.5% for individuals who reside in northern Kenya relative to those who live elsewhere in the country, all else equal.

21. A recent survey of 400 M-Pesa users in Nairobi showed that M-Pesa is primarily a payment tool, with the bulk (64%) of its users holding an average monthly balance of less than KES 1,000 (USD 8) and net balance (inflows minus outflows) of only KES 250 (USD 2), the results being robust to income levels and employment types. The data are available here. Since withdrawals and deposits must be made through an agent or through an automated teller machine (ATM), distance to the agent/ATM is more or less as important as distance to a financial institution, under these circumstances.

22. For example, for savings, the log of the odds ratio, *Usepdt* = log {*P*(*Savings*=1) / [1-*P*(*Savings*=1)]}.

23. See, e.g., Kenya National Bureau of Statistics Report (accessed 17.03.2022).

24. The test essentially compares the observed number of responses to the expected number of responses using cells defined by the covariate patterns. The further away are these two, the higher is the resulting chi-square statistic and the lower is its p-value. In this section, we ran the tests with the number of quintiles set at 20.

25. The link test is run by re-estimating the model using the predicted value and its square as explanatory/predictor variables. The predictor variable (hat) should be significant but not its square (hat-squared)—if hat-squared? is significant, it may signify the omission of (an) important variable(s) or inappropriate functional form of the estimated specification (Johnen and Mußhoff, 2022).

26. In some cases, the specialized agent may be created by a principal (e.g., government) specifically to facilitate financial inclusion: for example, the Indian government's 2016 *Jan Dhan Yojana* programme to encourage bank account ownership (Demirguc-Kunt et al., 2017) and the more recent *India Stack*, whose purpose was to bring India's population into the digital age (Das and Das, 2020), have ushered millions of hitherto excluded Indians into the formal financial system. In other cases, the specialized agent may emerge organically through "normal" product innovation to claim a place in the financial inclusion space (e.g., M-Pesa in Kenya).

27. https://financialmarketsjournal.co.za/enabling-financial-inclusion-through-fintech/ (accessed 20.03.2022).

28. We implemented the IV regression through the generalized method of moments (GMM) estimation. For robustness checks, we also ran three-stage least squares (3SLS) and IV-Probit estimation. Results were qualitatively similar.

29. Because we constructed *digital consumerism*, a component of the fintech ecosystem, to include "owner of the household has fixed interne at home", critiques may point to a possible double counting of "Internet". To deal with this, we also ran tests with ownership of a touchscreen phone as the sole instrument. The results were qualitatively similar.

30. For example, Kenya's premier fintech service provider, Safaricom, has introduced the "My Safaricom App", which it is tactfully nudging its fintech customers to prefer to its traditional GSM-based fintech service platforms both by levying an SMS charge on the traditional facility and by consolidating and offering all its services on the app. Since the app is Internet-based, there should be a close linkage between Internet usage and the app usage and, by extension, usage of Safaricom's fintech products.

References

Allen, F., A. Demirguc-Kunt, L. Klapper and M.S. Martinez Peria. 2016. "The foundations of financial inclusion: understanding ownership and use of formal accounts". *Journal of Financial Intermediation*, 27: 1–30.

Allen, F., E. Carletti, R. Cull, J.Q.J. Qian, L. Senbet and P. Valenzuela. 2021. "Improving access to banking: evidence from Kenya". *Review of Finance*, 25(2): 403–47.

Arner, D.W., R.P. Buckley, D.A. Zetzsche and R. Veidt. 2020. "Sustainability, fintech and financial inclusion". *European Business Organization Law Review*, 21(1): 7–35.

Aziz, A. and U. Naima. 2021. "Rethinking digital financial inclusion: Evidence from Bangladesh". *Technology in Society*, 64: 101509.

Bachas, P., P. Gertler, S. Higgins and E. Seira. 2018. "Digital financial services go a long way: Transaction costs and financial inclusion". *AEA Papers and Proceedings*, 108: 444–48.

Bin, Li., S.D. Hanna and K.T. Kim. 2020. "Who uses mobile payments: Fintech potential in users and non-users". *Journal of Financial Counselling and Planning*, 31(1), 83–100.

Bollaert, H., F. Lopez-de-Silanes and A. Schwienbacher. 2021. "Fintech and access to finance". *Journal of Corporate Finance*, 68: 101941.

Brailovskaya, V., P. Dupas and J. Robinson. 2021. "Digital credit: Filling a hole, or digging a hole? Evidence from Malawi". NBER Working Paper No. 29573. National Bureau of Economic Research (NBER), Cambridge, MA.

CBK. 2021. Banking sector innovation survey 2021. Nairobi: *Central Bank of Kenya.* Available at: https://www.centralbank.go.ke/wp-content/uploads/2020/03/Kenya-Banking-Sector-Charter-2019.pdf

Chakrabarty, M. and S. Mukherjee. 2021. "Financial inclusion and household welfare: An entropy-based consumption diversification approach". *European Journal of Development Research*, 34(3): 1486–1521.

Daniel, B. and D. Grissen. 2015. "Behavior revealed in mobile phone usage predict loan repayment". Department of Economics, Brown University, Working Paper Series. Brown University, Providence, Rhode Island.

Das, A. and D. Das. 2020. "Perception, adoption, and pattern of usage of fintech services by bank customers: evidences from Hojai District of Assam". *Emerging Economy Studies*, 6(1): 7–22.

Demir, A., V. Pesqué-Cela, Y. Altunba and V. Murinde. 2022. "Fintech, financial inclusion, and income inequality: a quantile regression approach". *European Journal of Finance*, 28(1): 86–107.

Demirgüç-Kunt, A. and L. Klapper. 2013. "Measuring financial inclusion: Explaining variation in use of financial services across and within countries". *Brookings Papers on Economic Activity*, 1: 279–340.

Demirguc-Kunt, A., L. Klapper, S. Ansar and A. Jagati. 2017. "Making it easier to apply for a bank account: A study of the Indian market". World Bank Policy Research Working Papers No. WPS8205. The World Bank, Washington, D.C., USA.

Dizon, F., E. Gong and K. Jones. 2020. "The effect of promoting savings on informal risk sharing: experimental evidence from vulnerable women in Kenya". *Journal of Human Resources*, 55(3): 963–98.

Dupas, P., D. Karlan, J. Robinson and D. Ubfal. 2018. "Banking the unbanked? Evidence from three countries". *American Economic Journal: Applied Economics*, 10(2): 257–97.

Gabor, D. and S. Brooks. 2017. "The digital revolution in financial inclusion: International development in the fintech era". *New Political Economy*, 22(4): 423–36.

Ghosh, S., 2022. Gender and financial inclusion: Does technology make a difference? *Gender, Technology and Development* 26(2), 195–213.

Ghosh, S. and D. Vinod. 2017. "What constrains financial inclusion for women? Evidence from Indian Micro data". *World Development 92:* 60–81. https://doi.org/10.1016/j.worlddev.2016.11.011

Grishchenko, N. 2020. "The gap not only closes: Resistance and reverse shifts in the digital divide in Russia". *Telecommunications Policy*, 44(8): 102004.

Grohmann, A., T. Klühs and L. Menkhof. 2018. "Does financial literacy improve financial inclusion? Cross country evidence". *World Development*, 111: 84–96.

GSMA, 2021. State of the industry report on mobile money 2021. GSMA Mobile for Development (M4D).

GSMA, 2022. State of the industry report on mobile money 2022. GSMA Mobile for Development (M4D).

Gulamhuseinwala, I., Bull, T., and S. Lewis. 2015. "FinTech is gaining traction and young, high-income users are the early adopters". *Journal of Financial Perspectives*, 3(3): 16–23.

Gwer, F., J. Odero and E. Totolo, E. eds. 2019. "Digital credit audit report: Evaluating the conduct and practice of digital lending in Kenya". *Financial Sector Deepening (FSD)* Kenya.

Hosmer Jr., D.W., S.A. Lemeshow and R.X. Sturdivant. 2013. *Applied Logistic Regression*. 3rd ed. Hoboken, NJ: Wiley.

Jack, W. and T. Suri. 2014. "Risk sharing and transactions costs: Evidence from Kenya's mobile money revolution". *American Economic Review,* 104(1): 183–223.

Jagtiani, J. and C. Lemieux. 2018. "Do fintech lenders penetrate areas that are undeserved by traditional banks?" Federal Reserve Bank of Philadelphia Working Paper Series. Federal Reserve Bank of Philadelphia, Philadelphia.

Johnen, C. and O. Mußhoff. 2022. "Digital credit and the gender gap in financial inclusion: Empirical evidence from Kenya". *Journal of International Development*, 35(2): 272–95.

Johnen, C., M. Parlasca and O. Mußhoff. 2021. "Promises and pitfalls of digital credit: Empirical evidence from Kenya". *Plos One*, 16(7): e0255215.

Kangwa, D., T.J. Mwale and S.M. Junaid. 2020. "Co-evolutionary dynamics of financial inclusion of generation Z in a Sub-Saharan digital financial ecosystem". *Copernican Journal of Finance & Accounting*, 9(4): 27–50.

Karanasios, S. 2018. "Toward a unified view of technology and activity: The contribution of activity theory to information systems research". *Information Technology and People*, 31(1): 134–55.

Kim, K.H. 2020. "The role of mobile money in improving the financial inclusion of Nairobi's urban poor". *African Journal of Science, Technology, Innovation and Development*, 12(7): 855–65.

KNBS/CBK/FSD. 2021. FinAccess Household Survey 2021. Nairobi: *Kenya National Bureau of Statistics,* November.

Kodongo, O. 2018. "Financial regulations, financial literacy, and financial inclusion: Insights from Kenya". *Emerging Markets Finance and Trade*, 54(12): 2851–73.

Lee, I. and Y.J. Shin. 2018. "Fintech: ecosystem, business models, investment decisions, and challenges". *Business Horizons*, 61(1): 35–46.

Liao, L., L. Ji and W. Zhang. 2015. "Education and credit: evidence from P2P lending platform". *Journal of Financial Research*, 3: 146–59.

Liébana-Cabanillas, F., J. Sánchez-Fernández and F. Muñoz-Leiva. 2014. "Antecedents of the adoption of the new mobile payment systems: the moderating effect of age". *Computers in Human Behavior* 35: 464–78.

Malaurent, J., and S. Karanasios. 2020. Learning from workaround practices: The challenge of enterprise system implementations in multinational corporations". *Information Systems Journal*, 30(4): 639–63.

Mallinguh, E., Z. Zoltan and H. Kecskes. 2017. "Innovative financial digital ecosystem: an evaluative study of Kenya". In K. Cebeci, A. Pawlicz and A. Altaher, eds.", MIRDEC - *6th International Academic Conference on Social Sciences, Multidisciplinary, Economics, Business and Finance Studies (Global Meeting of Social Science Community).* Lisbon, Portugal: MIRDEC. Retrieved from www.mirdec.com

Morgan, P.J. 2022. "Fintech and financial inclusion in Southeast Asia and India". *Asian Economic Policy Review* 17: 183–208.

Muralidhar, S.H., C. Bossen and J. O'Neill. 2019. "Rethinking financial inclusion: From access to autonomy". *Computer Supported Cooperative Work: An International Journal,* 28(3–4): 511–47.

N'dri, L.M. and M. Kakinaka. 2020. "Financial inclusion, mobile money, and individual welfare: The case of Burkina Faso". *Telecommunications Policy*, 44(3): 101926.

Natile, S. 2020. "Digital finance, inclusion, and the mobile money "social" enterprise". *Historical Social Research*, 45(3): 74–94.

Ntwiga, D.B. 2019. "Can fintech shape the dynamics of consumer credit usage among the un(der)banked?" KBA Centre for Research on Financial Markets and Policy Working Paper Series No. WPS/04/19). Kenya Bankers Association (KBA) Centre for Research on Financial Markets and Policy, Nairobi.

O'Neill, J., A. Dhareshwar and S.H. Muralidhar. 2017. "Working digital money into a cash economy: The collaborative work of loan payment". *Computer Supported Cooperative Work: An International Journal*, 26(4–6): 733–68.

Oborn, E., M. Barrett, W. Orlikowski A. and Kim. 2019. "Trajectory dynamics in innovation: developing and transforming a mobile money service across time and place". *Management Science,* 30(5): 869–1123.

Osoro, B.J. and D. Muriithi. 2018. "Financial inclusion: how do you know that you are there?" KBA Centre for Research on Financial Markets and Policy Working Paper Series No. WPS/03/18). Kenya Bankers Association (KBA) Centre for Research on Financial Markets

and Policy, Nairobi, Kenya.

Ozili, P.K. 2020. "Theories of financial inclusion". In E. Özen and S. Grima, eds., *Uncertainty and Challenges in Contemporary Economic Behaviour*. Emerald Studies in Finance, Insurance, and Risk Management. Emerald Publishing Limited. https://doi.org/10.1108/978-1-80043-095-220201008

Philippon, T. 2019. "On fintech and financial inclusion". NBER Working Paper Series. National Bureau of Economic Research (NBER), Cambridge, MA. Available: http://www.nber.org/papers/w26330

Platteau, J.-P., O. De Bock and W. Gelade. 2017. "The demand for microinsurance: A literature review". *World Development*, 94: 139–56.

Rauniyar, Kanchan, Rauniyar, Komal, and Sah, D. K. 2021. Role of FinTech and innovations for improvising digital financial inclusion. *International Journal of Innovative Science and Research Technology, 6*(5), 1419–1424.

Riley, E. 2018. "Mobile money and risk sharing against village shocks". *Journal of Development Economics,* 135: 43–58.

Senyo, P.K., S. Karanasios, D. Gozman and M. Baba. 2022. "Fintech ecosystem practices shaping financial inclusion: The case of mobile money in Ghana". *European Journal of Information Systems,* 31(1): 112–27.

Shaikh, A.A., R. Glavee-Geo, H. Karjaluoto and R.E. Hinson. 2023. "Mobile money as a driver of digital financial inclusion". *Technology Forecasting and Social Change*, 186: 122158.

SKOLKOVO., 2015. Digital platforms and the ecosystems of financial inclusion: The Russian experience. Moscow, Russia: *The Moscow School of Management, SKOLKOVO.* Available at SSRN: https://ssrn.com/abstract=3104644

Subramaniam, M., 2020. Digital ecosystems and their implications for competitive strategy. *Journal of Organization Design*, 9(12), 1–10.

Suri, T. and W. Jack. 2016. "The long-run poverty and gender impacts of mobile money". *Science*, 354(6317): 1288–92.

Yue, P., A.G. Korkmaz, Z. Yin and H. Zhou. 2022. "The rise of digital finance: Financial inclusion or debt trap?" *Finance Research Letters,* 102604.

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