

Examining the relationship between digital finance and financial inclusion: Evidence from MENA countries

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Abstract

Although financial inclusion (FI) has attracted growing attention from academics and policy makers, the effect of digital finance (DF) on FI has not been studied sufficiently. Therefore, this study examines the association between DF and FI in the Middle East and North Africa (MENA) region. FI is measured with a composite index incorporating three subindexes: access, availability, and usage of financial services; DF is measured by the number of ATMs per 100,000 adults. A system-generalized method of moments (sys-GMM) panel method is employed with annual data on 12 countries in the MENA region over the period 2004–2020. Additionally, five control variables are used in the study. The results confirm the role of DF in enhancing FI in the MENA countries. Policy makers and digital financial service providers in MENA countries can use the study's findings to expand the boundaries of FI in their countries.

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1. Introduction

The fourth Industrial Revolution (Industry 4.0) has contributed to a significant change in social and economic systems around the world. Industry 4.0 has improved data processing and its delivery and thus increases the quality and speed of decision-making (Bilan, Rubanov, Vasylieva, & Lyeonov, 2019). In addition, Industry 4.0 has introduced new human and machine competencies that depend entirely on technological infrastructure that supports the financial sector's digital transformation, leading to new electronic marketing channels and financial services (Mhlanga, 2020; Pakhnenko, Rubanov, Hacar, Yatsenko, & Vida, 2021). This modification was accelerated by the COVID-19 pandemic, which changed the operating standards of firms' work trends and enhanced the

potential for digital finance (Bede Uzoma, Omankhanlen, Obindah, Arewa, & Okoye, 2020).

Digital finance (DF) is considered a response to technological development in the financial sector. It involves all electronic financial services and products, including financing, investment, payment, insurance, and financial information delivered through digital channels (Gomber, Koch, & Siering, 2017; Ozili, 2018). On the one hand, DF has several benefits for the government, individuals, enterprises, and the economy. First, it offers a platform for the government to increase its total expenditure and tax revenue resulting from the growth of financial transactions (Manyika, Lund, Singer, White, & Berry, 2016; Ozili, 2018). Second, it boosts the growth of the gross domestic product (GDP) by expanding access to credit facilities for individuals and enterprises. It is expected that using DF could increase GDP by \$3.7 trillion in all economies in 2025 (Manyika et al., 2016). Third, it positively affects financial institutions' performance (Scott, Van Reenen, & Zachariadis, 2017). Financial institutions can save \$400 billion in direct costs by turning to digital services (Manyika

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et al., 2016). Finally, DF offers new channels for delivering a broader range of financial services to financially excluded groups (Demirgüç-Kunt, Klapper, Singer, & Ansar, 2018).

On the other hand, DF comes with additional risks, such as privacy, cybersecurity, and contractual risks resulting from the relationship between a financial institution and third parties (Mhlanga, 2020; Pakhnenko et al., 2021). Thus, to protect users, it is necessary to ensure appropriate technological infrastructure, regulatory legislation, and strict procedures. It is also necessary to design suitable services for first-time users of these services (Ozili, 2018).

Since 2010, when the leaders of the G20 recognized financial inclusion (FI), regulators and policy makers worldwide have become more interested in it as an enabler of global development. FI aims to ensure access and use of financial services and products in the formal financial system by all segments of society, thus ensuring their participation in economic growth and taking advantage of development (Ozili, 2020a). In addition, FI enables the achievement of the United Nations sustainable development goals (Ma'ruf & Aryani, 2019), promotes financial stability and economic growth (Neaime & Gaysset, 2018), and reduces income inequality and poverty (Park & Mercado, 2015; Turegano & Herrero, 2018). Although the global effort aims to enhance FI, widespread disparity exists among developing regions (Demirgüç-Kunt, Klapper, Singer, & Van Oudheusden, 2015; Lyons & Kass-Hanna, 2021; Neaime & Gaysset, 2018). However, DF could enhance FI by enabling financial transactions using cell phones, increasing access to finance for individuals and enterprises, and facilitating access to social protection funds for their recipients in rural areas (Gomber et al., 2017; Pearce, 2011).

The economies in the Middle East and North Africa (MENA) region is characterized by a high ratio of loan concentration, high financial depth, and low rate of adult account ownership, leading to limited access to finance for young and small firms (Emara & El Said, 2021; Pearce, 2011). According to Demirgüç-Kunt et al. (2015), just 14.0 percent of adults have a bank account compared with an average of 54.0 percent in other developing regions. FI's gender and youth gap are also bigger in the MENA region than in other developing areas (Lyons & Kass-Hanna, 2021). FI is necessary for the MENA region because many countries have recently witnessed conflicts and turmoil resulting from high unemployment, income erosion, and marginalization of a large segment of the population. Therefore, governments and policy makers in this region need to intervene and adopt strategies to enhance FI, thus achieving monetary stability and fostering economic growth (Emara & El Said, 2021; Neaime & Gaysset, 2018).

On the other hand, the digital transformation efforts in MENA countries have been bolstered by the remarkable increase in information and communication technologies (Bahrini & Qaffas, 2019). For example, internet use by people in the MENA region reached 66 percent, which is higher than the world average, and the penetration rate of mobile cellular phones reached 97.5 percent in 2021 (Bogdan-Martin, 2021).

Indeed, research on FI in MENA countries is scarce, suggesting the need for more studies to understand its determinants

in this region (Emara & El Said, 2021; Lyons & Kass-Hanna, 2021; Neaime & Gaysset, 2018). Moreover, the extent to which DF affects FI has not received enough attention in prior literature (Ozili, 2018; Siddik & Kabiraj, 2020). Consequently, this study aims to answer the following questions:

1. What is the overall level of financial inclusion in the MENA countries?
2. Do high- and middle-income countries in the MENA region differ in their level of financial inclusion?
3. How did digital finance affect financial inclusion in the MENA region from 2004 to 2020?

To the best of our knowledge, this is the first study on this issue covering the MENA region. This study contributes to the emerging literature on FI in different ways. It presents a comprehensive measurement of DF and FI over a seventeen-year period. In addition, this study is the first to empirically investigate the effect of DF on FI in the MENA region, where economic and political conflicts make FI challenging to achieve.

To achieve the study's goal, we use data on 12 MENA countries from 2004 to 2020. Because of the presence of country-specific effects in a sample of many countries, we employ the system-generalized method of moments (sys-GMM). We measure FI with a composite index consisting of three subindexes: access to financial services, availability of financial services, and use of financial services; we measure DF by the number of ATMs per 100,000 adults. Furthermore, we selected five control variables to determine their influence on FI. We perform a multicollinearity test, unit-root tests, the Arellano and Bond (1991) test, and the Sargan test to ensure the robustness of the results. The results confirm the role of DF in enhancing access and availability to and use of financial services in addition to the overall FI level in the MENA region. Moreover, the results of the *t*-test for the equality of means show that in the MENA region, high-income countries have more financial inclusion than middle-income countries.

The study's results offer a new theoretical background for understanding the relationship between DF and FI, which could provide an impetus for academics and researchers to undertake future studies in this area. Moreover, the study's results increase understanding and awareness by the central bank governors and digital financial services providers about the effect of DF on FI. Thus it provides empirical evidence to help build effective plans and strategies for promoting financial inclusion, considering the role of digital financial services in the MENA region.

The rest of this paper is organized as follows. Section 2 presents the theoretical and empirical literature, Section 3 explains the data and methodology used, Section 4 discusses the results, and Section 5 reports the conclusions.

2. Literature review

Because DF is a form of technological innovation, it is worthwhile to refer to the technology acceptance model (TAM)

proposed by Davis (1989), one of the most cited models in technology acceptance literature (Taherdoost, 2018). According to TAM, perceived usefulness and ease of use of new technology influence a person's attitude toward the technology. The attitude, in turn, affects the intention to use the technology, which determines actual use (Albastaki, 2022). Applying TAM in the context of DF shows that financial service providers offer reliable digital services 24 h a day, seven days a week, which is very useful for customers. In addition, digital platforms allow customers to perform financial transactions efficiently through applications on their cell phones. One of the limitations of TAM is that it focuses on the individual and ignores the process of social change (Legris, Ingham, & Collette, 2003). Thus, because DF and FI operate across society, this study is based on the diffusion of innovation theory (DIT) proposed by Rogers, Singhal, and Quinlan (2014). DIT explains the mechanism of the spread of innovation in which innovation is delivered to members of society through specific channels over time. According to DIT, the spread of any innovation depends on five factors: the innovation itself, innovation adopters, communication channels, time, and the social system. Unlike TAM, innovation adopters are not just individuals but also organizations and groups with social networks. The theory also identifies five stages of innovation adoption: knowledge, persuasion, decision, implementation, and confirmation. The failure of an innovation to spread does not mean that no one adopts it, but, rather, that it has failed to reach a total adoption rate because of weak innovation, competition from other innovations, or a lack of awareness (Albastaki, 2022; Yoon & Lim, 2020).

2.1. Conceptualization of digital finance

Despite the absence of a single definition of DF, a consensus has been reached that DF comprises all financial services and products delivered remotely by financial service providers. Manyika et al. (2016, p. 4) define DF as “financial services delivered over digital infrastructure with low use of cash and traditional bank branches.” Gomber et al. (2017) divide DF into three dimensions: business functions, technologies, and institutions. They state that technological applications, including blockchain, enable DF functions such as financing, investment, payment, and insurance, and digital service providers perform these business functions. Moufakkir and Mohammed (2020) write that, in developing countries, DF offers secure financial services at a reasonable price to unbanked populations, helping them move from using cash transactions to digital transactions and enhancing FI.

2.2. Conceptualization of financial inclusion

No specific definition is available for FI, and this is due to the various contexts in which FI is defined. Sarma and Pais (2011, p. 3) define FI as “a process that ensures the ease of access, availability, and usage of the formal financial system for all members of an economy.” This study follows the previous definition, which is comprehensive and based on three

specific dimensions of FI: accessibility, availability, and use of financial services. Demircuc-Kunt et al. (2015) state that participation by individuals in the financial system increases their ability to start businesses, control risk, and survive financial crises. Hence, international bodies such as the World Bank have encouraged policy makers worldwide to develop strategies and plans for enhancing FI as an enabler of sustainable economic growth and poverty reduction. However, Ozili (2020b) argues that, according to the public good theory of FI, financial services should be delivered to everyone in the population. To achieve FI, various stakeholders should jointly try to bring the financially excluded population into the formal financial system.

2.3. Digital finance and financial inclusion: theoretical perspective

Previous studies make various arguments regarding the relationship between DF and FI. On the one hand, Senou, Ouattara, and Acclassato Houensou (2019) write that, in developing countries, where most people have cell phones and internet connections, DF offers secure platforms for performing financial transactions, bringing them into the formal digital financial system. Moreover, in rural societies, where people cannot access traditional bank branches because of inadequate and high-cost transportation, financial service providers offer easy-to-use digital platforms that facilitate daily transactions (Moufakkir & Mohammed, 2020). Consequently, poor and financially excluded people increase their confidence in the formal financial system's institutions and persuade their peers to use digital financial services, thus increasing FI (Bede Uzoma et al., 2020). However, this positive relationship is weakened in low-income societies because people refuse to use digital services. This refusal has many reasons, including financial illiteracy, high fees, religious concerns, and irrational attitudes toward technology and innovation (Ozili, 2018). Demircuc-Kunt, Klapper, and Randall (2014) argue that Muslims prefer to deal with financial products that comply with Islamic law (sharia), which forbids the earning of interest on financial products and thus influences the extent to which they participate in the conventional formal financial system.

On the other hand, Ozili (2018) argues that financial service providers seek to maximize their profitability by offering digital services. Accordingly, they direct their marketing activities toward high- or middle-income customers because they believe that low-income customers cannot afford the cost of digital services, which leads to a decrease in FI due to the exclusion of this segment of society. In addition, in developing countries, which lack consumer protection, people avoid using DF based on their lack of trust in digital service channels because of their concern about data security, which negatively affects financial inclusion plans in these countries (Malady, 2016). In this regard, Ozili (2018) states that the cost of securing customer data could be higher than the returns from the provision of digital services, making DF infeasible for digital financial service providers. Moreover (Yue, Korkmaz, Yin, & Zhou, 2021),

believe that because digital financial services are more complex and riskier than traditional financial services, customers need to be financially literate to use digital services. Hence, financially illiterate customers limit their use of digital services, which has a negative effect on FI. (Mouna & Jarboui, 2021) recommend cooperation between the government and financial institutions to facilitate access to financial resources and to overcome obstacles that prevent the adoption of technological channels by providers and users of financial services.

2.4. Digital finance and financial inclusion: empirical evidence

As mentioned before, few studies empirically investigate the relationship between DF and FI. However, our review of the previous studies reveals two strands.

The first concentrates on the relationship between technology use and FI. Mushtaq and Bruneau (2019) use panel data from 62 countries to examine how ICT decreases poverty and inequality by promoting FI. They assess two kinds of FI: commercial banks and microfinance institutions. They measure the FI of microfinance institutions by the ratio of the gross loan portfolio to GDP, and the number of borrowers divided by the total population measure the FI of commercial banks by the bank deposits and borrowers per capita. The results show that most ICT indicators decrease poverty and income inequality by promoting FI. Using data from 186 countries, Fanta and Makina (2019) examine the relationship between technology and FI. and measure two dimensions of FI: access to financial services proxied by bank accounts per 1000 adults and use of financial services proxied by electronic fund transfer and deposits as a percentage of GDP. They report a positive impact of automatic teller machines (ATMs) and internet technology on access and use of financial services, concluding that technology significantly impacts FI. Agyekum, Reddy, Wallace, and Wellalage (2021) measure the effect of ICT services on FI by access to a line of credit using a sample of small and medium-size enterprises in Southeast Asian countries, finding a positive relationship between ICT use and FI. Kouladoum, Wirajing, and Nchofoung (2022) use data from 43 sub-Saharan African countries to investigate the relationship between digital technology and FI. They measure digital technology by four ICT indicators and FI by an indicator comprising the number of bank accounts per 100,000 adults, the number of bank branches, and ATMs users per 100,000 adults. They find that all digital technology indicators have a positive effect on FI, stressing the vital role of digital technology in enhancing FI.

The second strand of previous studies focuses on the relationship between DF and FI. Ene, Abba, and Fatokun (2019) investigate the effect of electronic banking on FI in Nigeria. They use two proxies for electronic banking, the number of ATMs used per year and the number of point-of-sales (POS) machines used a year, and measured FI by the share of the bankable population with access to the formal financial system. The results show a positive relationship between POS systems and FI, concluding that electronic banking enhances FI in

Nigeria. Bede Uzoma et al. (2020) use data from 27 sub-Saharan African countries to investigate the relationship between DF measured by the share of people using ATMs and FI measured by actual use and quality of financial services. They use deposit accounts in commercial banks for every 1000 adults to measure actual use of financial services and the ratio of depositors to borrowers to measure actual use of financial services. The results reveal a positive association between DF and FI. This result is supported by the findings of Siddik and Kabiraj (2020), who examine the influence of DF on FI using data on 189 countries from 2004 to 2016. Shen, Hueng, and Hu (2020) look at the effect of financial literacy, DF product usage, and internet use on enhancing FI in China. They report that financial literacy and the use of DF products have a direct positive impact on FI. In contrast, they find that the relationship between internet usage and FI is indirect, concluding that internet use enhances FI through the role of the internet in offering DF products.

Base on our literature review, no prior study has examined the relationship between DF and FI in the MENA region. Therefore, to achieve the objective of the study, we propose the following hypothesis:

Hypothesis 1. *Digital finance has a positive impact on financial inclusion in the MENA region.*

3. Data, variables, and econometric model

Based on the data available to measure the variables for the period 2004 to 2020, this study focuses on 12 MENA countries: Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, and the UAE. The data for measuring DF and FI come from the International Monetary Fund's Financial Access Survey (FAS) database, which covers 189 countries and includes 121 time series on access to and use financial services. In addition, data from the World Development Indicators (WDI) database and the United Nations development reports are used to measure the control variables.

This study examines the relationship between DF and FI. Thus the dependent variable of the study is FI. Following Sarma (2008), we develop a Financial Inclusion Index (FII) to measure FI in three dimensions: access to, availability of, and use of financial services. Subindexes measure each dimension of FI as follows: the Access Subindex (ACI) is measured by the number of deposit accounts at commercial banks per 1000 adults, the Availability Subindex (AVI) is measured by the number of ATMs per 100,000 square kilometers, and the Use Subindex (USI) is measured by the ratio of outstanding loans from commercial banks to GDP. We use the following equation to measure these subindexes:

$$SI_i = \frac{V_i - \text{Min } i}{\text{Max } i - \text{Min } i}$$

where SI_i is the subindex of dimension i , V_i is the actual value of dimension i , $\text{Min } i$ is the minimum value of dimension i , and

Table 1
Variable definitions.

Variable	Measurement	Source
Financial Inclusion	Financial Inclusion Index	FAS ^a
Digital Finance	Number of ATMs per 100,000 adults	FAS
Income Level	Log of gross domestic product per capita	WDI ^b
Inflation	Change of consumer price index	WDI
Internet Usage	Proportion of the population using the Internet	WDI
Socioeconomic Environment	Human development index	UN Developments Report
Legal Protection	Legal right index	WDI

^a Financial Access Survey issued by the International Monetary Fund.

^b World Development Indicators issued by the World Bank.

Max_{*i*} is the maximum value of dimension *i*. When the value of SI_{*i*} is higher, so is the country's position in dimension *i*. Then, the FII for each country is measured using the following equation:

$$FII_i = 1 - \frac{\sqrt{(1 - ACI_i)^2 + (1 - AVI_i)^2 + (1 - USI_i)^2}}{\sqrt{3}}$$

where FII_{*i*} is the financial inclusion index for country *i*, ACI_{*i*} is the access subindex for country *i*, AVI_{*i*} is the availability subindex for country *i*, and USI_{*i*} is the use subindex for country *i*. The value of FII is between 0 and 1, in which 0 is low FI and 1 is high FI. DF is the independent variable, measured by the number of ATMs per 100,000 adults. This measurement is also used by Siddik and Kabiraj (2020) and Bede Uzoma et al. (2020).

We include five control variables based on the previous literature to capture their effect on FI in the MENA region. GDP per capita (GDPC) measures the income level. People in higher-income countries are expected to be more integrated into the financial system, positively affecting FI (Sha'ban, Girardone, & Sarkisyan, 2020). The level of inflation (INF) is measured by the change in the consumer price index (CPI). High inflation is accompanied by uncertainty, which negatively affects the supply and demand levels in the economy, and thus it is expected to affect FI negatively (Kouladoun et al., 2022). In addition, we include a variable for internet use (INU), which is measured by the share of the population that uses the internet. The expansion in the availability of the internet helps improve delivery and access to various financial services, which contributes to the integration of financially excluded individuals into the formal financial system and thus enhances FI (Sha'ban et al., 2020). The human development index (HDI) is included to capture the influence of the socioeconomic environment. HDI, calculated by the United Nations, comprises three dimensions: health, education, and the standard of living. A high level of education increases people's awareness and tendency to use financial services, leading to an increase in FI. In addition, an improvement in the standard of living enables people to increase their savings at banks, which encourages banks to expand the provision of their financial services to a larger segment of customers, thus increasing FI (Datta & Singh, 2019). Finally, we add the legal protection of borrowers and lenders (LP), which is expected to influence FI

positively. It is measured by the legal right index, which evaluates the degree to which collateral and bankruptcy laws protect borrowers and lenders (Grohmann, Klühs, & Menkhoff, 2018). Table 1 defines the variables in the study.

Following Bahrini and Qaffas (2019), we use sys-GMM to estimate the coefficients of the variables. However, unlike conventional panel regression methods, sys-GMM can deal with the issue of country-specific effects with a sample of many countries (Arellano & Bond, 1991). Accordingly, we constructed the following models:

$$ACI_{i,t} = \beta_0 + \beta_1 ACI_{i,t-1} + \beta_2 DF_{i,t} + \beta_3 Z_{i,t} + \delta_i + \varepsilon_{i,t} \quad (1)$$

$$AVI_{i,t} = \beta_0 + \beta_1 AVI_{i,t-1} + \beta_2 DF_{i,t} + \beta_3 Z_{i,t} + \delta_i + \varepsilon_{i,t} \quad (2)$$

$$USI_{i,t} = \beta_0 + \beta_1 USI_{i,t-1} + \beta_2 DF_{i,t} + \beta_3 Z_{i,t} + \delta_i + \varepsilon_{i,t} \quad (3)$$

$$FI_{i,t} = \beta_0 + \beta_1 FI_{i,t-1} + \beta_2 DF_{i,t} + \beta_3 Z_{i,t} + \delta_i + \varepsilon_{i,t} \quad (4)$$

where ACI_{*i,t*}, AVI_{*i,t*}, and USI_{*i,t*} denotes access, availability, and use of financial services of country *i* at time *t*, respectively. FI_{*i,t*} denotes financial inclusion in country *i* at time *t*. DF_{*i,t*} is a vector of digital finance in country *i* at time *t*, Z_{*i,t*} represents the control variables of country *i* at time *t*, δ_{*i*} denotes unobserved country-specific effects, and ε_{*i,t*} is the error term. β₁ is the coefficient to be estimated to assess any potential effect of the lagged ACI_{*i,t-1*}, AVI_{*i,t-1*}, USI_{*i,t-1*}, and FI_{*i,t-1*} on its current level. β₂ is the coefficient to be estimated to evaluate any significant impact of DF on ACI, AVI, USI, and FI during the period studied, and β₃ represents the coefficient to be estimated for each control variable.

4. Results and discussion

4.1. Descriptive results

Table 2 reports the summary statistics for the variables for the sample of 12 countries from 2004 to 2020. The data show a variation in the level of FI across the countries in the sample,

Table 2
Descriptive statistics.

Variable	Mean	Std. Dev.	Min.	Max
Number of deposit accounts with commercial banks per 1000 adults	802.27	284.32	303.96	1427.45
Number of ATMs per 1000 sq. km.	39.29	49.10	0.12	195.80
Ratio of outstanding commercial loans to GDP	86.82	30.54	27.76	184.25
Financial inclusion index	0.25	0.30	0.12	0.67
Number of ATMs per 100,000 adults	35.30	19.39	2.65	81.07
Gross domestic product per capita (log)	6.20	2.32	5.12	9.86
Change of consumer price index	4.42	5.70	-2.09	78.43
Proportion of the population using the internet	76.59	4.15	62.9	99.12
Human development index	0.72	0.17	0.01	0.89
Legal right index	2	3.45	1	6

Table 3
Results of *t*-test for the equality of means.

Variable	High-income countries	Middle-income countries	Difference in mean
	Mean	Mean	
Number of deposit accounts with commercial banks per 1000 adults	1032.51	440.72	380***
Number of ATMs per 1000 sq. km.	53.85	4.37	364***
Ratio of outstanding commercial loans to GDP	98.45	42.51	262**
Financial inclusion index	0.46	0.18	190**

Notes: *, **, and *** significant at 10 percent, 5 percent, and 1 percent, respectively. High-income countries include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. Middle-income countries include Algeria, Egypt, Morocco, Tunisia, Jordan, and Lebanon.

with a minimum value of 0.12 in FII and a maximum value of 0.67. Among the subindexes of FI, ACI has the highest standard deviation, indicating a high variation in the number of deposit accounts at commercial banks per 1000 adults across the countries in the sample, with a minimum of 304 and a maximum of 1427. The mean number of ATMs per 1000 sq. km. is 39, and the mean ratio of outstanding commercial loans to GDP is 87 percent. With respect to DF, the mean value of the number of ATMs is 35 per 100,000 adults, which is relatively low compared with the maximum value of 81. Among the control variables, the change in the CPI has the highest standard deviation, indicating high variation between countries in terms of the price level, whereas the human rights index has the lowest standard deviation.

Table 3 shows the results of the *t*-test for the equality of means, with FI statistics differentiating between high- and middle-income countries. The data show that, among all the variables, high-income countries have the most financial inclusion, with the most significant difference noted in the number of deposit accounts and ATMs. In this context, Lyons and Kass-Hanna (2021) find that economically vulnerable populations in the MENA region, who live in countries with a high financial literacy rate, are more likely to participate in formal borrowing and saving activities.

4.2. Regression results

To ensure the robustness of our results, we conduct several statistical tests. The variance inflation factor (VIF) is used to detect multicollinearity problems. In all the estimations, the VIF is less than 3, which indicates the absence of

multicollinearity. To test for stationarity, we use two different panel unit-root tests: the IPS test by Im, Pesaran, and Shin (2003) and the LLC test by Levin, Lin, and Chu (2002). The results in Table 4 report that DF is integrated of order one and that the remaining variables are integrated of order zero. The IPS test shows that DF and HDI are integrated of order one, and the rest of the variables are integrated of order zero. Furthermore, we use the Arellano and Bond (1991) test of first- and second-order serial correlation and the Sargan test for overidentifying restrictions. The Arellano and Bond (1991) test results in Table 5 show that errors in the first-difference regression exhibit no second-order serial correlation. Moreover, the Sargan test rejects the null hypothesis that the overidentifying restrictions are valid in the models.

Table 5 shows the empirical results from the model estimations. In Model (1), access to financial services is the dependent variable. The results show that DF has a significant effect on the number of deposit accounts at commercial banks per 100,000 adults, which implies that DF is associated with

Table 4
IPS and LLC unit-root test results.

Variable	Level		First differences	
	IPS	LLC	IPS	LLC
DF	0.6900	3.6121	4.7090***	19.4071***
GDPC	2.3104**	11.4130***	6.6203***	32.0703***
INF	2.0030**	10.3503***	5.5320***	26.3043***
INTU	2.3013***	11.4040**	6.7083***	31.6012***
HDI	2.0040	10.9730***	5.4034***	27.7231***
LP	2.0713	11.1191***	5.7142***	25.1654***

Notes: *** and ** significant at 1% and 5%, respectively.

Table 5
Regression results.

Variable	Model (1)	Model (2)	Model (3)	Model (4)
$ACI_{i,t-1}$	0.9460*** (0.015)			
$AVI_{i,t-1}$		0.7220** (2.2030)		
$USI_{i,t-1}$			0.0601** (3.6612)	
$FII_{i,t-1}$				0.0450** (3.3320)
DF	0.0370** (0.0012)	0.0123** (0.0050)	0.0313** (0.0100)	0.9401*** (0.0201)
GDPC	0.7671*** (0.0121)	0.0710*** (0.0040)	0.0144** (0.0061)	0.0270*** (0.0051)
INF	0.0444 (0.0520)	0.0750 (0.1112)	0.0052 (0.0063)	-0.1500*** (0.0042)
INTU	0.0140** (0.0062)	0.0030** (0.0011)	0.0140** (0.0062)	0.5480*** (0.0200)
HDI	0.0004 (0.0013)	0.0060 (0.0071)	0.0093** (0.0033)	0.0140 (0.0400)
LP	0.0131** (0.0052)	0.0034 (0.0071)	0.0070*** (0.0024)	0.0110 (0.0321)
Arellano-Bond test for AR(1) (<i>p</i> -value)	0.0220	0.0009	0.0380	0.7040
Arellano-Bond test for AR(2) (<i>p</i> -value)	0.1842	0.2873	0.3603	0.9112
Sargan test (<i>p</i> -value)	0.2341	0.1876	0.2202	0.2110
Observations	180	176	178	181

Notes: ***, **, and * significant at 1%, 5% and 10%, respectively. Standard errors are reported in parentheses.

accessing financial services. In Model (2), in which the availability of financial services is the dependent variable, the results show a significantly positive relationship between DF and the number of ATMs per 1000 sq. km., which implies that DF has a positive impact on the availability of financial services. This positive effect is consistent with the results by [Fanta and Makina \(2019\)](#) and inconsistent with the argument by [Ozili \(2018\)](#), who states that the availability of digital financial services does not necessarily lead to access to these services, especially in developing countries, where individuals prefer to execute financial transactions in banks directly, instead of using high-cost digital services.

In Model (3), in which use of financial services is the dependent variable, the results show that DF and the ratio of outstanding commercial loans to GDP have a significantly positive relationship. This result suggests that the use of financial services increases with an increase in DF. Lastly, in the expectations line, a significantly positive relationship between DF and FI in the MENA region implies that DF enhances FI. This result is consistent with the findings by [Kouladoun et al. \(2022\)](#); [Siddik & Kabiraj, 2020](#)). In this regard, [Ozili \(2018\)](#) emphasizes the role of complete financial

data in supporting DF and enhancing FI. He argues that the digital banking credentials of financially excluded populations could be linked to digital payment channels offered by financial service providers and thus used for financial transactions. However, this transfer to digital services is driven by user trust, financial awareness, and low cost.

Among the control variables, the coefficient of GDPPC is significant and positive in all models. This result indicates that the country's income level has a positive impact on access, availability, financial service use, and overall FI. As expected, we find a significantly negative relationship between inflation and the overall FI level. The results in all models also have a positive coefficient for internet use, indicating the vital role of internet diffusion in fostering FI. This result is inconsistent with [Shen, Hu, and Hueng \(2018\)](#), who report an insignificant relationship between internet usage and FI in China.

Furthermore, we find a significantly positive relationship between HDI and use of financial services. This result is in line with the view that the level of education and financial literacy is related to the ability of customers to make conscious financial decisions to protect themselves from abusive financial practices ([Lyons & Kass-Hanna, 2021](#)). Finally, we find a

Table 6
Recommendations of the study.

Recommendation	Implementation of recommendation	Expected result	Implementation body
Increase financial awareness	Execute specialized financial programs targeting students at schools, institutions of higher education, and in rural areas	Increase the number of bank accounts and the volume of loans granted	The financial inclusion units at central banks
Increase customers' awareness of digital financial services	Implement promotional campaigns that target conventional financial service providers	Increase the number of digital financial services users	Management of digital financial service providers
Improve the digital infrastructure of digital financial services	Stimulate and support digital financial innovations	Increase the volume of digital payments and transactions at the national level	Technical support centers at central banks and financial institutions
Review legislation governing digital financial services	Implement joint legal initiatives to review and update digital financial services legislation	Issue modern legislation regulating digital financial work	Legal departments of central banks and financial service providers

significantly positive coefficient for the legal right index in Models (1) and (3), which shows evidence of a positive association between legal protection for lenders and borrowers and access to and use financial services.

5. Conclusion

This study examines the effect of DF on FI in 12 MENA countries during the period 2004 to 2020. The study measures FI with a composite index encompassing three subindexes: access to, availability of, and use of financial services, whereas DF is measured by the number of ATMs per 100,000 adults. Other variables were employed as determinants of FI, such as income level, inflation, internet use, HDI, and legal protection. Sys-GMM is used to assess the coefficient estimates of the variables.

Our findings show that DF enhances access to, availability of, and use of financial services in the MENA region and the overall FI level. Our findings lead us to make several recommendations, as shown in Table 6.

To build on our work, future studies could examine the risks digital financial services present for users and their effect on the financial sector. It is also worth investigating the potential influence of financial literacy as a moderating variable that could affect the relationship between DF and FI. Furthermore, for a more profound understanding of the relationship between DF and FI, a comparative study is suggested between the MENA region and another regional bloc.

Declaration of competing interest

The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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