

BANK EFFICIENCY AND FINTECH-BASED INCLUSIVE FINANCE: EVIDENCE FROM DUAL BANKING SYSTEM

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ABSTRACT

This paper examines the relation between fintech-based inclusive finance and bank efficiency using annual unbalanced data of 318 banks from 7 dual-banking countries over the period of 2011 to 2020. It measures bank efficiency using the data envelopment analysis (DEA) and then applies the Simar-Wilson bootstrapping regression to measure the influence of fintech-based financial inclusion on bank efficiency. From the efficiency measures, we note that Islamic banks are more efficient than their conventional counterparts. Our regression analysis indicates that fintech-based inclusive finance is positively related to bank efficiency, implying that greater implementation of digitally integrated financial system improves banking efficiency. Our findings are robust to alternative estimation methods. Our study provides some policy implications for policymakers, standard setters, and regulators.

Keywords: Bank efficiency, Fintech, Inclusive finance, Dual-banking, Access to finance.

JEL classification: C34; C38; E44; F65; G28.

Article history:

Received : July 31, 2022

Revised : October 25, 2022

Accepted : February 28, 2023

Available online : March 21, 2023

<https://doi.org/10.21098/jimf.v9i1.1621>

I. INTRODUCTION

Recent worldwide lockdown has shown the importance of staying connected through technology. Though every aspect of life is affected by technology, the question is often whether the increased use of technology is beneficial or harmful. Financial technology (FinTech) is not exempt from this question and has quickly become a widely studied area in finance literature. Along with FinTech, another issue taking center stage is financial inclusion, or inclusive finance. Financial inclusion means that participants in financial intermediation will have full access to all the possible financial instruments and sources of information, leading to reduced costs of financing and alleviated asymmetric information, an increase in employment and financial stability, and efficiency. As banks have learned the hard way after the financial crisis of 2007-08, more investment in financial technologies has been made to diversify financing sources from risky wholesale deposits to cheap and stable retail deposits (Demirguc-Kunt & Huizinga, 2010).

The comprehensive implementation of fintech-based inclusive finance (FIF) will likely spur the overall financial development of a country through ensuring banking efficiency (Banna, 2020). Apprehending the undeniable importance of FIF during the current COVID-19 crisis, the head of Digital Regulation at BBVA¹ Mr. Pablo Urbiola states, "The experience of the last few months leaves us with a lot of useful lessons that can be used to map out the future of Europe's digital finance strategy" (Alvarez, 2020). Foreseeing its necessity, policymakers worldwide, including governments and multilateral development agencies such as the IMF, World Bank, and central bankers, advance procedures to integrate financial technologies to ensure a higher degree of financial inclusivity, which helps break down racial, religious, ethnic, and geographic barriers to socioeconomic development (Klapper et al., 2016), which can ultimately lead to more efficient banks.

FinTech's role in inclusive finance is essential and relevant to our study. In order to understand if FinTech-based inclusive finance affects bank efficiency, inclusive finance or financial inclusion must first be defined and understood. The Federal Reserve provides a description of inclusive finance as well as information related to FinTech's role. Allen et al. (2020) define financial inclusion as "the use of formal financial services, especially by the disadvantaged" (Allen et al., 2020, p.11). They find that FinTech plays an essential role in inclusive finance. One specific example is Kenya, where Equity Bank provides almost half the population with deposit accounts, which helps many individuals who previously lacked access to financial means. This increased access helps with growth, not only in Kenya but also in other African countries. Another study, touched on by the Federal Reserve, talks about how businesses and individuals who are unable to get funding from traditional sources rely on FinTech lenders instead.

Notwithstanding the importance of FIF on bank efficiency, there is limited research exploring the specific linkages between fintech-based inclusive finance and bank efficiency, mainly due to the lack of time-series FIF data across countries. Empirical studies on bank efficiency have focused largely on various affecting

¹ Banco Bilbao Vizcaya Argentaria (BBVA) is a Spanish multinational financial services company based in Madrid and Bilbao, Spain. It is one of the largest financial institutions in the world and is present mainly in Spain, South America, North America, Turkey, and Romania.

factors of bank efficiency, while most studies on financial inclusion have primarily concentrated on various socio-economic indicators (e.g., Butler & Cornaggia, 2011; Demirgüç-Kunt et al., 2013; Demirgüç-Kunt et al., 2013; Han & Melecky, 2013; Hannig & Jansen, 2010; Morgan & Pontines, 2018; Xu, 2020) at a macro-level. Studies on the financial inclusion and bank efficiency nexus are few as financial inclusion is a relatively new concept and many countries have started focusing on it to implement policies only after the GFC. A very few studies (e.g., Ahamed et al., 2021; Banna et al., 2021; Banna & Alam, 2020; Ozili, 2018; Sahay et al., 2020) have explored the importance of inclusive finance on bank efficiency. However, they have concentrated on financial inclusion in general rather than fintech-based inclusive finance and found mixed results. Hence, the limited empirical research and both positive and negative results of FI/FIF-bank efficiency interconnectedness, the recent global financial crisis (GFC 2007-09) and the present COVID-19 pandemic motivate us to combine the two topics and ask, Does FinTech-based inclusive finance matter for bank efficiency? The main objective of this research is to examine the link between bank efficiency and FinTech-based inclusive finance (FIF) in countries with a dual banking system perspective. It intends to see whether the relationship differs between Islamic and conventional banks.

Our study provides numerous contributions to the literature. This study uses the DEA methodology together with a bias-corrected Simar-Wilson (2007) bootstrapping technique to find the link between bank efficiency and FIF using dual banking data. Unlike other studies, this study specifically adds value to the literature by providing a comparative analysis to see the differences in bank efficiency and FIF nexus for Islamic and conventional banks using the most recent data (2011-2020). Moreover, this study uses both supply-side (access to fintech-based finance) and demand-side (usage of fintech-based finance) to measure the FIF index to see its impact on bank efficiency, which will enhance the existing literature pertinent to inclusive finance and bank efficiency. The use of alternative econometric techniques (for example, Bias-corrected Simar-Wilson, Tobit, Fractional Probit, and IV-Tobit regressions) further add credence and methodological improvement to the literature on the subject. Finally, this study contributes to the regulators and central banks by providing empirical evidence whether fintech-based inclusive finance is vital for the banks to improve their efficiency.

The rest of the paper is organized as follows. The following section 2 reviews the literature (theoretical background and empirical evidence). Section 3 discusses the data and the methodology, while section 4 presents the results. Finally, section 5 concludes the study by providing recommendations.

II. LITERATURE REVIEW

The nexus between finance and growth goes back to the Theory of Economic Development, published in 1911 by Joseph Alois Schumpeter. More specifically, Schumpeter shows the contribution of entrepreneurship, as a form of innovation, to economic development, although it is a debatable issue (Fagerberg, 2003). Innovation always brings blessings and promotes development. As Schumpeter states, “carrying out innovations is the only function which is fundamental in

history” though later he considers it a ‘creative destruction’ (Śledzik, 2013). After the theory of Schumpeter, King & Levine (1993) empirically demonstrate that financial development fosters economic growth. In the same vein, many studies (e.g., Beck et al., 2014; Cecchetti & Kharroubi, 2012; Favara, 2003; Levine, 2005; Levine & Zervos, 1998) have been carried out to show the nexus between financial development and economic growth.

Inclusive financial services have emerged into the fore after the GFC of 2007-09. Inclusive finance, or FI, seems to be incomplete without the latest innovation of digital finance that is being implemented gradually in the overall banking industry. Easily accessible and affordable financial services executed by the financial sector have the capacity to reduce agency problems along with reducing the information asymmetries between creditors and debtors (Beck et al., 2014). Moreover, the inclusive finance is also capable of minimizing the volatility of the funding of the banking sector as it helps banks collecting more deposits from more clients, which ultimately increases the liquidity of the banking sector (Han & Melecky, 2013). Through the expansion of financial services, banks are seen reducing the volatility of returns as they refrain from more costly and risky money market funds (Kacperczyk & Schnabl, 2013).

On the other hand, inclusive finance augments agency problems because of the structure of the organization and different types of products, as well as decreases banking efficiency when the head office of the bank is far away from the branch, which obstructs it from supervising the activities of the branch on a regular basis (Brickley et al., 2003). Hence, studies show both the negative and positive impacts of inclusive finance on the banking sector. However, the majority of the studies (e.g., Ahamed & Mallick, 2019; Banna et al., 2022; Danisman & Tarazi, 2020; Vo et al., 2021) show wider inclusion or more financial products and services with proper regulation has a significant positive impact on banking efficiency.

Bank efficiency is shown to improve with financial inclusion. Ahamed et al. (2021) look at 1,740 banks from 86 countries and evaluate the connection between financial inclusion and the efficiency of banks. The authors use data from the IMF’s Financial Access Survey (FAS) to capture financial inclusion development, and country-level data is gathered from the World Development Indicators (WDI) provided by the World Bank. They implement a DEA to measure bank efficiency and find a positive correlation between bank efficiency and financial inclusion. Furthermore, in a slightly more niche international approach, Banna et al. (2021) and Banna & Alam (2020) explore financial inclusion within Islamic banks and its effect on banking efficiency. The authors explore the time period following the 2008 crisis by considering the DEA approach. They also find a positive relationship between bank efficiency and financial inclusion.

A connection between banking and FinTech requires a review of the interaction between the two, which is precisely what Thakor (2019) covers. With the current growth of specialized fintech firms, traditional banks face fierce competition. To fully understand this, we must first determine if FinTech includes technology-assisted products that are being provided by banks. In his paper, Thakor excludes them from the definition of FinTech; with this exclusion, an estimated 8,800 FinTech companies existed as of November 2016. A major question the author reviews is how to include FinTech in current financial intermediation theories. The author

also suggests that P2P lending will not replace banks, but P2P lending will take more of the market share. This decrease in market share creates a critical need for banks to act efficiently when dealing with FinTech (Thakor, 2019).

Jagtiani & Lemieux (2017) evaluate the connection between FinTech lenders and customers as well as the current banking environment. One of the main findings focuses on the impact Lending Club has in areas that may lack access to traditional banks. Even with the same level of default risk, loans through the Lending Club, a FinTech lender, have lower rates, meaning customers can access funds at a lower cost. Overall, FinTech lenders are shown to provide loans and other needed financial assistance to individuals who previously did not have financial access. Though FinTech is viewed as a threat to some extent, the authors conclude that traditional banks and FinTech lenders are collaborating to increase financial inclusion, and the loans provided by FinTech lenders are “appropriately risk-priced,” reducing any fears of a future crisis. FinTech has become a major player in increasing financial inclusion (Jagtiani & Lemieux, 2017).

The research on FinTech and financial inclusion, like all financial endeavors, is not exclusive to the United States. Sahay et al. (2020) evaluate the impact of FinTech-driven financial inclusion across 52 countries from 2014 to 2017. The most significant impacts are observed in Africa and Asia. Sahay et al. (2020) present a way to measure digital financial inclusion through payments and the creation of two indices. The index contains a summary of digital payment services through cell phones and the internet.

The majority of the literature focuses on various factors of financial inclusion, aspects of bank efficiency, correlation between financial inclusion and bank efficiency; however, studies on fintech-based inclusive finance and bank efficiency, specifically with regard to the dual banking system, are scarce. Hence, this study will investigate the relationship between fintech-based inclusive finance and bank efficiency using dual banking data with a comparative focus on the Islamic banking industry.

III. METHODOLOGY

3.1. Data and Variables

This study gathers data from three different sources - Moody’s Analytic BankFocus, IMF’s Financial Access Survey and World Bank’s Findex and World Development Indicator (WDI) over the period of 2011 to 2020. In the study, we consider countries with a dual banking system (conventional and Islamic banks), where initially they are Bangladesh, Bahrain, Brunei Darussalam, Indonesia, Iran, Kuwait, Malaysia, Nigeria, Pakistan, Qatar, Saudi Arabia, Sudan, Turkey, and United Arab Emirate. These countries make up 95% of the Islamic banking assets (Banna & Alam, 2021). However, due to the unavailability of FIF data for various countries, our final sample comprises only seven countries, namely Bangladesh, Indonesia, Malaysia, Nigeria, Pakistan, Qatar, and Sudan. The final sample consists of annual unbalanced panel data from 318 banks (245 conventional banks and 73 Islamic banks). Table 1 shows the sample breakdown in which Indonesia (37%) carries the highest percentage and Qatar (4%) carries the lowest percentage of the sample. Below, we explain the variables used in the study:

Table 1.
Sample breakdown

Country	Number of banks	Sample (%)	Number of conventional banks	Number of Islamic banks
Bangladesh	56	17.61	47	9
Indonesia	117	36.79	106	11
Malaysia	50	15.72	31	19
Nigeria	27	8.49	26	1
Pakistan	35	11.01	26	9
Qatar	12	3.77	7	5
Sudan	21	6.60	2	19
Total	318	100	245	73

Source: Author's

Bank Efficiency: We employ the DEA approach to estimate the efficiency of the banks in the sample (Charnes et al., 1978). It is a non – parametric linear programming method used in economic and operations research to analyze the relative efficiency of decision – making units (DMUs) with a number of inputs and outputs. In this study, each individual bank represents one single DMU. For the selection of appropriate input and output variables for the model, there have been no clear specifications that have been identified for banks to determine these variables. Therefore, following Ahamed et al. (2021), we use total deposits and short – term funding, fixed assets, and staff expenses as the bank inputs for the DEA model. For the bank outputs, we use bank loans, other earning assets, and other operating income. The DEA model under the variable return to scale (VRS) developed by Banker et al. (1984) is applied to generate our efficiency scores for each DMU (bank). The score ranges from 0 to 1, with 0 representing the least efficient bank and 1 representing the most efficient bank.

Fintech – based inclusive finance index (FIF): Our main independent variable is the Fintech – based inclusive finance index (FIF index). The index is constructed using the principal component analysis (PCA) and data from IMF – FAS and the Global Findex. The FIF index has been identified to have two main indicators: Access and Usage of financial services. Due to the scarcity of direct proxies for these measures, we consider variables that are related to digital financial activities to create FIF indices. Following Ahamed & Mallick (2019); Banna et al., (2021), we construct a comprehensive FIF index by taking into account the number of mobile money agent and non-branch commercial bank agent outlets, mobile money accounts, and mobile and internet banking transactions (For more details please see Banna et al., 2021).

Bank and Macro - economic variables: We use a number of bank controls based on banking literature, such as bank SIZE, management quality, capitalization, and loan ratio. The Size is captured using the logarithm of total assets. The size control is to account for the size effect on a bank's efficiency. Better management quality is essential for the efficiency of banks. As a proxy of the Management Quality we use the ratio of total earning assets to total assets. To measure how capitalized a bank is and account for capital risk, we control for Capitalization. Finally, the loan ratio

(the ratio of total loans over total assets) is included to account for the liquidity risk of the banks. As for country – specific variations, we employ three macroeconomic variables: GDP growth rate to control for economic growth; unemployment rate and inflation to account for economic uncertainty. All the macroeconomic variables are obtained from the World Bank Open Database.

3.2. Empirical Model

To examine the impact of fintech-based inclusive finance on bank efficiency, we specify the following baseline model:

$$Y_{ijt} = \alpha + \beta FIF_{jt} + \phi X_{ijt} + \omega Z_{jt} + \varepsilon_{ijt}$$

Where, Y_{ijt} = bank efficiency of bank i of country j in year t , FIF_{jt} = Fintech-based inclusive finance of country j in year t , X_{ijt} = Bank-specific factors of bank i of country j in year t , Z_{jt} = Macroeconomic factors of a country j in year t . β , ϕ , ω = Coefficients of the variables and ε_{ijt} = Error term.

To estimate the relationship between DEA efficiency score and its determinants (in this case like FIF and other control variables) using conventional methods such as Tobit, Probit, OLS etc may yield measurement error as DEA estimation is sequentially correlated with an additional source of endogeneity as well as provides bias results (Banna & Alam, 2020; Daraio et al., 2018). To solve the estimation problem and bias results, Simar & Wilson (2007) recommend double bootstrap technique. Hence, following Banna & Alam (2020) and Ahamed et al. (2021), we employ the Simar-Wilson double bootstrapping technique for the baseline model estimation. Still, we also use fractional Probit, Tobit, and Tobit Instrumental variables regression for the robustness of the study.

IV. RESULTS AND ANALYSIS

4.1. Results

4.1.1. Descriptive Statistics

Table 2 shows the descriptive statistics of variables used in the study. Notably, the mean efficiency of the sample banks is 0.569, of which Islamic banks hold a slightly higher average value (0.626) as compared to conventional banks (0.558). During COVID-2020, Islamic banks carry a higher (on average) efficiency score (0.785) as compared to their conventional counterparts (0.698). In terms of the FIF indices, the average scores are 0.185 (overall), 0.17 (access), and 0.122 (usage). Besides, the average asset size of sample banks is 6.8 billion USD, with Islamic banks have on average the asset size of 4.2 billion USD and conventional banks 7.6 billion USD.

Table 2.
Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
Efficiency	3522	0.569	0.301	0.014	1
FIF_Overall	2555	0.185	0.25	0	1
FIF_Access	2555	0.17	0.276	0	1
FIF_Usage	2555	0.122	0.24	0	1
Bank Size	3522	7.397	1.734	0.351	12.548
Management Quality	3522	0.814	0.144	0.009	0.997
Capitalization	3522	0.137	0.141	-1.547	0.992
Loan Ratio	3522	0.571	0.192	0	2.022
GDP growth	3522	5.287	2.676	-2.504	26.17
Inflation	3521	6.914	7.046	-6.811	63.293
Unemployment	3522	4.923	3.505	0.11	17.71

4.1.2. Bank Efficiency and Fintech-based Inclusive Finance

As our main objective is to examine the link between bank efficiency and FIF, following Banna & Alam (2020) and Ahamed et al. (2021), we consider the bias-corrected Simar-Wilson double bootstrapping regression.

Table 3.
Simar-Wilson Double Bootstrapping Regression (Full Sample)

	(1)	(2)	(3)
	Efficiency	Efficiency	Efficiency
FIF_Overall	0.214*** (0.023)		
FIF_Access		0.036 (0.022)	
FIF_Usage			0.210*** (0.023)
Bank Size	0.108*** (0.004)	0.115*** (0.004)	0.108*** (0.004)
Management Quality	0.688*** (0.053)	0.674*** (0.054)	0.719*** (0.052)
Capitalization	0.529*** (0.041)	0.572*** (0.043)	0.509*** (0.039)
Loan Ratio	-0.445*** (0.035)	-0.446*** (0.037)	-0.454*** (0.035)
GDP growth	-0.005 (0.003)	-0.001 (0.004)	0.006** (0.003)
Inflation	0.005*** (0.001)	0.004*** (0.001)	0.007*** (0.001)
Unemployment	-0.004 (0.003)	-0.004 (0.003)	-0.005* (0.003)
Obs.	2085	2085	2085
Year dummies	yes	yes	yes

Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

The results in table 3 display that FIF (overall) has a positive and significant relationship with bank efficiency at a 1% level of significance. The findings suggest that with an increase in fintech-based inclusivity, banks tend to have higher efficiency. While decomposing the FIF index into its access and usage dimensions, the results show that FIF (access) has a positive but insignificant relationship with bank efficiency and FIF (usage) has a positive and significant relationship with bank efficiency (at a 1 % level of significance).

Table 4.
Simar-Wilson Double Bootstrapping Regression (Conventional vs Islamic)

	(1)	(2)	(3)	(4)	(5)	(6)
Dep: Efficiency	Commercial bank	Islamic bank	Commercial bank	Islamic bank	Commercial bank	Islamic bank
FIF_Overall	0.165*** (0.026)	0.194*** (0.045)				
FIF_Access			0.144*** (0.024)	-0.198*** (0.054)		
FIF_Usage					0.131*** (0.028)	0.248*** (0.044)
Bank Size	0.122*** (0.004)	0.053*** (0.009)	0.126*** (0.004)	0.065*** (0.009)	0.123*** (0.004)	0.052*** (0.009)
Management Quality	0.647*** (0.060)	0.887*** (0.096)	0.578*** (0.063)	0.969*** (0.110)	0.650*** (0.058)	0.827*** (0.103)
Capitalization	0.702*** (0.043)	0.157** (0.077)	0.740*** (0.049)	0.105 (0.084)	0.702*** (0.050)	0.144* (0.077)
Loan Ratio	-0.482*** (0.036)	-0.456*** (0.109)	-0.489*** (0.037)	-0.419*** (0.102)	-0.484*** (0.037)	-0.414*** (0.089)
GDP growth	0.001 (0.004)	-0.009 (0.006)	-0.013** (0.005)	0.009 (0.008)	0.011*** (0.003)	-0.003 (0.005)
Inflation	0.005** (0.002)	0.004** (0.002)	-0.004 (0.003)	0.004*** (0.002)	0.008*** (0.003)	0.005** (0.002)
Unemployment	-0.016*** (0.005)	-0.004 (0.004)	-0.013** (0.005)	-0.001 (0.004)	-0.018*** (0.005)	-0.005 (0.004)
Obs.	1643	442	1643	442	1643	442
Year dummies	yes		yes		yes	

Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

4.1.3. Islamic vs Conventional Banks and FIF

Table 4 shows the findings of the FIF-conventional banks' efficiency nexus and FIF-Islamic banks' efficiency nexus. The findings show that the efficiency of both conventional and Islamic banks has a positive and significant relationship with the FIF (overall) at a 1% level of significance. The decomposition of the index shows that the nexus of FIF (access)-conventional banks' efficiency is positive and significant, whereas the nexus of FIF (access)-Islamic banks' efficiency is negative

and significant. Moreover, the nexus of FIF (usage) – bank efficiency for both Islamic and conventional banks is positive and significant.

4.2. Robustness Tests

In order to validate our findings, we employed alternative estimation procedures. Namely, apart from the above Simar-Wilson bootstrapping regression, we use the fractional Probit regression, Tobit regression, and Tobit-Instrumental variable regression.

Table 5.
Fractional-Probit Regression

	(1)	(2)	(3)
	Efficiency	Efficiency	Efficiency
FIF_Overall	0.655*** (0.130)		
FIF_Access		0.060 (0.093)	
FIF_Usage			0.655*** (0.135)
Bank Size	0.195*** (0.044)	0.212*** (0.044)	0.194*** (0.044)
Management Quality	1.489*** (0.394)	1.507*** (0.400)	1.572*** (0.397)
Capitalization	1.508*** (0.458)	1.564*** (0.470)	1.459*** (0.460)
Loan Ratio	-0.646 (0.424)	-0.649 (0.428)	-0.667 (0.422)
GDP growth	-0.059*** (0.018)	-0.045** (0.017)	-0.030* (0.017)
Inflation	0.010** (0.004)	0.006 (0.004)	0.015*** (0.004)
Unemployment	-0.028* (0.016)	-0.022* (0.016)	-0.029* (0.016)
Obs.	2490	2490	2490
Pseudo R ²	0.128	0.121	0.128
Year dummies	Yes	yes	Yes

Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

Tables 5 and 6 show the results of Fractional Probit regression and Tobit regression. The results show that FIF (overall) -bank efficiency nexus and FIF (usage) - bank efficiency nexus are positive and significant at a 1% level, whereas FIF (access) - bank efficiency nexus is positive but insignificant. The results are similar to our baseline model, which means the results are robust.

Table 6.
Tobit Regression

	(1)	(2)	(3)
	Efficiency	Efficiency	Efficiency
FIF_Overall	0.267*** (0.054)		
FIF_Access		0.019 (0.040)	
FIF_Usage			0.266*** (0.054)
Bank Size	0.073*** (0.016)	0.080*** (0.016)	0.073*** (0.016)
Management Quality	0.603*** (0.153)	0.618*** (0.157)	0.637*** (0.154)
Capitalization	0.448** (0.180)	0.462** (0.190)	0.427** (0.182)
Loan Ratio	-0.312* (0.161)	-0.314* (0.163)	-0.319** (0.160)
GDP growth	-0.025*** (0.007)	-0.019*** (0.007)	-0.013** (0.007)
Inflation	0.003** (0.001)	0.001 (0.002)	0.005*** (0.001)
Unemployment	-0.009 (0.006)	-0.006 (0.006)	-0.009 (0.006)
Obs.	2490	2490	2490
Pseudo R ²	0.519	0.477	0.520
Year dummies	yes	yes	yes

Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

The endogeneity problem is addressed in this study by using the two-step IV-Tobit regression. To find suitable instruments, we search the literature extensively. Following the literature, we consider two instrument variables to be used in different models. 'Women-Job' represents how easily a woman can get a job or start a profession legally. In line with Ahamed et al. (2021), we believe that gender openness might be connected to inclusion. Following Medina and Schneider (2018), we also consider 'shadow economy', defined as the share of the informal economy as a percentage of GDP, as the second instrument. The percentage of the shadow economy might be connected to FIF, which may serve as a strong instrument variable.

Table 7.
Two-step IV-Tobit Regression

	(1)	(2)	(3)
	Efficiency	Efficiency	Efficiency
FIF_Overall	0.580*** (0.066)		
FIF_Access		2.213*** (0.509)	
FIF_Usage			0.490*** (0.061)
Bank Size	0.063*** (0.004)	0.066*** (0.007)	0.065*** (0.004)
Management Quality	0.578*** (0.065)	0.232 (0.159)	0.637*** (0.063)
Capitalization	0.403*** (0.042)	0.630*** (0.095)	0.377*** (0.042)
Loan Ratio	-0.289*** (0.040)	-0.364*** (0.070)	-0.293*** (0.039)
GDP growth	-0.035*** (0.004)	-0.289*** (0.063)	-0.007* (0.004)
Inflation	0.007** (0.003)	-0.096*** (0.021)	0.014*** (0.004)
Unemployment	-0.039*** (0.006)	0.026 (0.016)	-0.044*** (0.006)
Obs.	2363	2363	2363
Year dummies	Yes	yes	Yes

Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

The results in Table 7 show that, while considering instrumental variables, overall, the results have improved as compared to our main results. The FIF (overall) – bank efficiency nexus and FIF (usage) – bank efficiency nexus are both still positive and highly significant. Interestingly, the FIF (access) – bank efficiency nexus has now become significant.

Besides, we also run the two-step dynamic Tobit-GMM regression² and find similar results. We also run the above regression for the conventional banks and Islamic banks separately and find similar results to our baseline results. Hence, our findings remain consistent even after going through a series of robustness tests.

4.3. Analysis

Bank efficiency is very important for both conventional and Islamic banking sectors. With the emergence of a dual banking system in many countries, it is

² Results are available upon reasonable request.

absolutely necessary to see differences in bank efficiency between the conventional and Islamic banking types. Our findings suggest that Islamic banks operate with higher efficiency as compared to their counterparts in the sample countries even during the peak of the COVID-19 crisis. Our findings are in line with Bitar et al. (2021) and Banna et al. (2021), who also find that Islamic banks are in a good position in terms of efficiency as compared to conventional banks.

The results of bank efficiency and fintech-based inclusive finance (FIF) suggest that an increase in the FIF index helps to increase the level of bank efficiency. Economically, it suggests that fintech-based inclusive finance has a great impact on bank efficiency, which means FIF enriches the soundness of individual banks in the sample countries. This suggests that a digitally inclusive financial sector can play a significant role in a bank's efficiency by enhancing financial soundness and financial mobility. These findings are similar to the previous studies (e.g., Ahamed et al., 2021; Banna and Alam, 2021; Morgan & Pontines, 2018) that show an inclusive financial system can help to boost banking efficiency by generating sufficient cheap retail deposits and mitigating the financial constraints of SMEs and individuals, as well as increasing financial mobilization. Therefore, it is suggested that banks need to focus more on fintech-based services such as open banking, peer-to-peer lending etc. to compete with other existing fintech-based non-bank firms to maintain their efficiency. Though it is quite difficult to say whether bank can be completely replaced with fintech-based firms, it is certainly a good idea to implement fintech-based services, even banks can collaborate with non-bank fintech firms. By doing so, banks can certainly minimize their operational cost (Banna et al., 2021).

The decomposition of the index suggests that the positive association with the efficiency of banks may be due to the rise in mobile and internet banking, which has eventually enhanced and maximized efficiency of banks (Banna et al., 2021). However, the insignificant relationship between FIF (access) and bank efficiency suggests that banks still need to widen their outreach by improving the access of the poorest and most remote parts of countries to financial services in the sample countries. The findings also suggest that Islamic banks are more sensitive than conventional banks in terms of the FIF-bank efficiency relationship. Though the FIF (overall, usage) - bank efficiency nexus is significantly positive for both bank types, the FIF (access) - bank efficiency nexus is negative for Islamic banks. This suggests that Islamic banks are still in the early phases of fintech-based development, hence, having high establishment and high operating costs, including capital, communication, and coordination costs, which ultimately reduce efficiency (Banna & Alam, 2021; Wang et al., 2021).

As a result, a digitally integrated financial system for both conventional and Islamic banks ensures banking soundness, reduces financial constraints, and increases financial mobility, which ultimately improves bank efficiency.

V. CONCLUSION AND RECOMMENDATIONS

This paper examines the relationship between fintech-based inclusive finance and bank efficiency by considering dual banking data over the period of 2011 to 2020. The results suggest that Islamic banks are more efficient than their counterparts

in the sample countries. The findings also suggest that Islamic banks are more sensitive than conventional banks and an increase in the FIF index increases the efficiency of the bank, which means a higher implementation of fintech-based financial services enhances banking efficiency. Our results remain significant in various robustness tests.

The positive relationship between Fintech-based FIF and bank efficiency suggests that policymakers, standard setters, and regulators consider a digitally integrated financial system as an effective tool for increasing banking efficiency. Therefore, regulators and central banks may enforce individual banks to implement digitally integrated financial system which will ultimately increase the efficiency of the bank. Given the mixed results of the FIF (access) – bank efficiency nexus, banks, particularly Islamic banks, should improve their digital services by implementing fintech-based services (e.g., artificial intelligence, machine learning, peer-to-peer lending etc.) and expanding agent services. Based on the results, it is highly recommended that apart from individual bank, the government and the central bank (for examples, Bank Indonesia, Bank Negara Malaysia, Bangladesh Bank etc.) of the sample countries should take the necessary steps to bring the unbanked people into formal banking by providing better services in terms of cyber-security protection and arranging various awareness campaigns.

In this study, we restrict our sample size due to data unavailability, which can be extended in the future by expanding the sample size to see more evidence. Future research can also be expanded by examining the risk management strategies of fintech-based solution provided by the Islamic banks, evaluating the role of government regulations in promoting or hindering the growth of fintech-based inclusive finance initiatives or assessing the current regulatory frameworks, and comparing the performance between Islamic fintech firms and fintech firms owned Islamic banks etc.

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