RESEARCH ARTICLE

Financial inclusion and its influence on economic-environmental performance: demand and supply perspectives

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Abstract

In this study, we want to test the impact of financial inclusion on the economic growth and the environmental quality of OBOR economies. We have selected four different proxies of financial inclusion, two from the perspective of the supply side and two from the perspective of the demand side. For empirical analysis, we have applied 2SLS and GMM methods. In the economic growth model, among the variables of financial inclusion, only the variable of ATMS is positively significant in the 2SLS approach; however, when we apply the GMM approach, two variables, i.e., ATMS and branches, are positively significant implying that supply-side financial inclusion is vital for economic growth in OBOR countries. On the other side, the variables of financial inclusion, whether supply side or demand side, exerted a positive impact on the CO_2 emissions irrespective of the estimation techniques, i.e., 2SLS and GMM. These findings imply that financial inclusion, in general, causes CO_2 emissions to rise.

Introduction

Financial inclusion is considered an effective determinant that can reduce income inequality and poverty (Park et al. 2018). The theories of financial inclusion reveal that financial inclusion is directly associated with inequality and economic growth (Ozili 2020). The theory proposes that the activities of entrepreneurs are primarily determined by their abilities, not by their parental wealth (Dermirguc-Kunt and Levine, 2009). Researchers highlighted various direct

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and indirect transmission channels through financial inclusion can mitigate poverty and reduce income inequality. Direct channel reveals that when people get access to have their bank accounts for buildings credit worth and saving, they become able to smooth their consumption patterns and become capable of handling adverse financial shocks (Sharma, 2016a, b). Afterward, credit access and savings could be used for the development of micro-enterprise and education of children that could reduce income inequality and poverty for current and future generations and thus enhance the overall economic growth of the nation (Van et al., 2021 and Zhao et al. 2021a, b). However, the indirect effect transmits through the channel of the labor market. It is argued that financial inclusion raises competition that results in reducing costs of intermediation and thus widens credit access to potential entrepreneurs. New jobs created due to the expansion of business from new entrepreneurs contribute to enhancing economic growth. Mushtaq and Bruneau (2019) study revealed that income inequality reduces significantly through the indirect channel of the labor market as compared to the direct channel. Thus, the study concluded that economic growth enhances more through the indirect channel of financial inclusion.

Hence, it is proven that financial inclusion is important due to its significant effects on economic growth. The

literature provides empirical evidence on the association between economic growth and financial inclusion (Kim 2016). Additionally, very few studies have explored the impact of different pillars of financial inclusion such as the banking sector, bonds, equity, and insurance on economic growth. Henceforth, the breakup of financial inclusion into these pillars permits the examination of how to do different pillars of financial inclusion influence economic growth. Financial inclusion influences economic growth through the channel of the economic mechanism (Emara & El Said, 2021). Financial inclusion enables households to increase savings and human capital and also smooth their pattern of consumption. Moreover, financial inclusion improves economic growth through the channel of the financial mechanism, as financial inclusion allows businesses to get access to finance easily for expanding their investment and business in the long term, thus generating more employment opportunities and improving economic growth. Le et al. (2020) stated that financial inclusion is an inextricable and significant part of the economic growth process. Financial inclusion boosts economic development as it contributes to enhancing the growth of institutions and financial sectors. Li (2018) highlighted that non-availability of finance is the major cause behind poverty.

Literature reported that financial inclusion also influences environmental performance. There are very limited studies considering the contribution of financial inclusion in reducing CO_2 emissions, due to the unavailability of data on financial inclusion. However, several studies have reported the impact of financial development on CO_2 emission such as Le et al. (2020) for Asia; Chaudhry et al. (2021) for OIC; and Mehmood (2021) for South Asia. Literature reported that the impact of financial inclusion on carbon emissions could be positive and negative. Earlier literature reported that the nexus between financial inclusion and CO_2 emissions is still puzzling, but the direction is clear among financial inclusion and economic growth in Table 1. Financial inclusion provides access to affordable and useful schemes to individuals and businesses that make investment more feasible for green technological innovation (Ullah et al. 2021 and Usman et al. 2021). Thus, financial inclusion brings favorable effects on the environment by increasing affordability and accessibility that contribute significantly to increasing environmental quality. Furthermore, the promotion of financial inclusion is specifically more relevant and beneficial for poor economies (Yang et al. 2020 and Li et al. 2022a, b).

Baulch et al. (2018) denoted that financial constraints such as lack of financial support from financial institutions, banks, and governments are considered as significant barriers in the way to solving environmental issues in Vietnam. However, the easy access and affordability of financial services and produce can promote the adoption and utilization of clean energy consumption and production services that reduce burnings from fossil fuels sources and ultimately mitigate CO_2 emissions (Zhao et al. 2021a, b). Additionally, increased access to finance boosts and aids industrial and manufacturing activities that tend to higher carbon emissions, thus increasing greenhouse gas emissions. Financial inclusion also increases the affordability of households to afford more energy-intensive goods such as air conditioners, refrigerators, and automobiles that cause higher carbon emissions, which contribute to environmental degradation. Frankel and Romer (1999) added that financial inclusion boosts economic activities that increase the demand for pollution-generating sources, thus increasing CO_2 emissions.

One belt and one road initiative (OBOR) have been implemented by the Chinese government in 2013 which is composed of developing and developed economies such as Asia, Europe, and Africa. OBOR economies are among the fast-growing economies of the world and are also considered the most dynamic region. Although OBOR economies have achieved significant growth in financial inclusion, still the region is facing the challenge of a shortage of finance. While the World Bank (2018) reported that there exist a lot of intra-country and across-country differences in the region and the promotion of financial inclusion can be a possible solution for OBOR regions. This study found the impact of digital financial inclusion on environment-economic performance that is one of the important contributions of the study.

Econometric model, methods, and data

This study examines the impact of financial inclusion on economic and environmental performance in OBOR economies. Therefore, we have taken the basic form of economic growth and CO_2 emissions and hence can be written as

$$\text{Economic growth}_{it} = \beta_0 + \beta_1.\text{FIS}_{it} + \beta_2.\text{FID}_{it} + \beta_3.\text{IND}_{it} \\ + \beta_4.\text{AG}_{it} + \beta_5.\text{EC}_{it} + \beta_6.\text{FDI}_{it} + et_{it} \tag{1}$$

$$CO_{2_{it}} = \beta_0 + \beta_1.\text{FIS}_{it} + \beta_2.\text{FID}_{it} + \beta_3.\text{IND}_{it} \\ + \beta_4.\text{AG}_{it} + \beta_5.\text{EC}_{it} + \beta_6.\text{FDI}_{it} + et_{it} \tag{2}$$

In the above models (1 and 2), the $\text{Economic growth}_{it}$ represent economic growth and $CO_{2_{it}}$ is CO_2 emissions of country (i) in period (t). FIS_{it} is financial inclusion supply side and FID_{it} is financial inclusion demand side of county in period t, respectively. The supply and demand sides of financial inclusion are taken as an independent variable of economic and environmental performance. The inclusion of control variables is based on the theoretical and empirical literature; thus, we used industrialization (IND), agriculturalization (AG), energy consumption (EC), and foreign direct investment (FDI). The supply and demand of financial

Table 1 Summary of literature

Author(s)	Country/regions	Data period	Methods	Variables	Results
Kim (2016)	Global	2004–2011	2SLS	Financial inclusion and economic growth	Positive
Makina & Walle (2019a, b)	Africa	2004–2014	GMM	Financial inclusion and economic growth	Positive
Dahiya & Kumar (2020)	India	2005–2017	VAR	Financial inclusion and economic growth	Positive
Ahmad et al. (2021a)	China	2011–2018	FE and Driscoll & Kraay	Financial inclusion and economic growth	Positive
Emara & El Said (2021)	MENA	1990–2018	GMM	Financial inclusion and economic growth	Positive
Sharma (2016a, b)	India	2004–2013	VAR	Financial inclusion and economic growth	Positive
Van et al. (2021)	Global	2004–2015	GMM	Financial inclusion and economic growth	Positive
Kim et al. (2018)	OIC	1990–2013	VAR	Financial inclusion and economic growth	Positive
Sethi & Acharya (2018)	Global	2004–2010	FEM and REM	Financial inclusion and economic growth	Positive
Pradhan et al. (2021)	India	1991–2018	FMOLS	Financial inclusion and economic growth	Positive
Erlando et al. (2020)	Indonesia	2010–2016	VAR	Financial inclusion and economic growth	Positive
Chatterjee (2020)	Global	2004–2015	GMM	Financial inclusion and economic growth	Positive
Le et al. (2020)	Asia	2004–2014	Driscoll-Kraay	Financial inclusion and CO2 emissions	Positive
Renzhi & Baek (2020)	Global	2004–2014	GMM	Financial inclusion and CO2 emissions	Positive
Qin et al. (2021)	E7	2004–2016	Quantile regression and GMM	Financial inclusion and CO2 emissions	Negative
Zaidi et al. (2021)	OECD	2004–2007	CS-ARDL	Financial inclusion and CO2 emissions	Negative
Liu et al. (2021)	China	1995–2019	ARDL	Financial inclusion and CO2 emissions	Negative
Mehmood (2021)	South Asian	1990–2017	CS-ARDL	Financial inclusion and CO2 emissions	Positive
Zhao et al. (2021a, b)	China	2011–2018	FEM	Financial inclusion and CO2 emissions	Negative
Chaudhry et al. (2021)	OIC	2004–2018	Dynamic Common Correlated Effects	Financial inclusion and CO2 emissions	Positive

inclusion variables are expected to be a positive impact on economic growth, while it can be a negative or positive impact on the environment. The basic panel model can be written as new famous panel dynamic models. Thus, Eqs. (1 and 2) become:

$$\text{Economic growth}_{it} = \beta_0 + \delta_1 . \text{Economic growth}_{it-1} + \beta_1 . FIS_{it} + \beta_2 . FID_{it} + \beta_3 . IND_{it}$$
$$+ \beta_4 . AG_{it} + \beta_5 . EC_{it} + \beta_6 . FDI_{it} + et_{it} \quad (3)$$

$$CO_{2_{it}} = \beta_0 + \delta_1 . CO_{2,it-1} + \beta_1 . FIS_{it} + \beta_2 . FID_{it} + \beta_3 . IND_{it}$$
$$+ \beta_4 . AG_{it} + \beta_5 . EC_{it} + \beta_6 . FDI_{it} + et_{it} \quad (4)$$

As our data is based on panel settings and we are applying two-stage least squares (2SLS) and generalized method of moments (GMM). Twin methods have some additional advantages over classic panel methods. The 2SLS approach is the extension of the OLS, and it is famous in panel data analysis. Fixed-effects (FE) and random-effects (RE) estimators fail to deal with the econometric issues of endogeneity and hence leads to inconsistent results (Bonnefond 2014). The 2SLS and GMM estimators help us to resolve the possible issues of endogeneity related to some elements of financial development such as the reverse causality, measurement error, and omitted variables problem. Endogeneity

is one of the significant issues in research in less developed countries. In specific, the estimation of the economic growth model may have various problems (Emara and El Said 2021). GMM provides better results than non-instrumental approaches (Ullah et al. 2021), while the additional instruments of the GMM method are found to reduce the sample size of the panel model (Blundell and Bond 1998). The GMM is one of the robust methods in the nexus of financial inclusion, economic growth, and environmental quality (Makina & Walle 2019a, b). For diagnostic statistics, we also use the Sargan and AR(2) tests for the validity of instruments and second-order autocorrelation.

The study investigates the role of financial inclusion in the nexus of environmental-economic performance for OBOR economies for time period ranging from 2007 to 2019. Table 2 contains a detailed discussion regarding definitions and abbreviations of variables and sources of data. Data for the empirical task is obtained from the World Bank and IMF. CO_2 emissions are used to measure environmental performance; it is measured in kilotons. Economic performance is measured through GDP growth which is an annual percentage of GDP growth. The financial deepening will help to achieve a sustainable environment (Li et al, 2022a, b). Bank size is also a really crucial factor regarding banking sector performance in the pre and post COVID-19 era (Xie et al, 2021). Bank branches and ATMs are supply-side variables of financial inclusion, while credit cards and debit cards are demand-side variables of financial inclusion. Bank branches and ATMs are taken as per 100,000 adults. However, credit cards and debit cards are measured as cardholders above 15 years age. The trend of financial inclusion variables is also reported in Fig. 1. All figures describe only the top fifteen countries due to conserving space out of 43 countries in our sample. Due to this reason, countries vary in each figure. The study contains a few control variables such as industry value added, agriculture value added, energy consumption, and foreign direct investment. Data on industry value added is measured as industry value added

as percent of GDP including construction, while data on agriculture value added is taken as agriculture, forestry, and fishing value added as percent of GDP. Energy consumption is measured as a total percentage of fossil fuel energy consumption. Foreign direct investment is taken as net flow of FDI (% of GDP). Table 3 provides outcomes of descriptive statistics and correlation matrix of variables. The mean of economic growth, CO_2, ATMs, branches, credit, debit, AG, IND, EC, and FDI are 3.82%, 11.1kt, 53.6, 18.6, 13.9%, 38.3%, 8.69%, 30.5%, 79.2%, and 4.12%, respectively. Table 3 shows Pearson's correlation matrix of independent variables, which infer that explanatory variables are free from multicollinearity. Findings indicate a higher correlation among ATMS, credit, and debit model variables. However, this high correlation does not infer the problem of multicollinearity among variables because these are proxies of financial inclusion, which are regressed in separate models.

Results and discussion

As the study is examining the impact of financial inclusion on environmental and economic performance for OBOR economies, in this regard, Table 4 depicts the empirical evidence of financial inclusion and economic performance, and Table 5 represents the findings of financial inclusion and environmental performance relationship. The study is taking into account the demand-side and supply-side perspectives of financial inclusion. ATMs and bank branches are used to measure the supply-side impact, and credit cards and debit cards are used to measure the demand-side impact of financial inclusion. The study adopts 2SLS and GMM techniques for empirical investigation. The 2SLS estimates in Table 4 demonstrate that a 1 percent increase in ATMs enhances the economic performance approximately by 0.020 percent. However, the results report no effect of bank branches, credit cards, and debit cards on economic performance in OBOR economies. In the case of control variables, the industry

Table 2 Definitions and source

Variables	Symbol	Definitions	Sources
GDP growth	Economic growth	GDP growth (annual %)	World bank
CO_2 emissions	CO_2	CO_2 emissions (kt)	World bank
ATMs	ATMS	ATMs per 100,000 adults	IMF
Bank branches	Branches	Bank branches per 100,000 adults	IMF
Credit card	Credit	Credit card (% age 15+)	IMF
Debit card	Debit	Debit card (% age 15+)	IMF
Industry value added	IND	Industry (including construction), value added (% of GDP)	World bank
Agriculture value added (% of GDP)	AG	Agriculture, forestry, and fishing, value added (% of GDP)	World bank
Energy consumption	EC	Fossil fuel energy consumption (% of total)	World bank
Foreign direct investment	FDI	Foreign direct investment, net inflows (% of GDP)	World bank

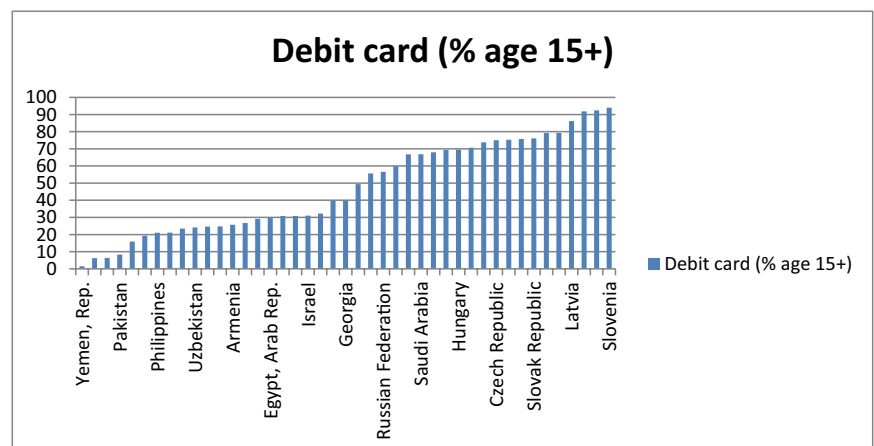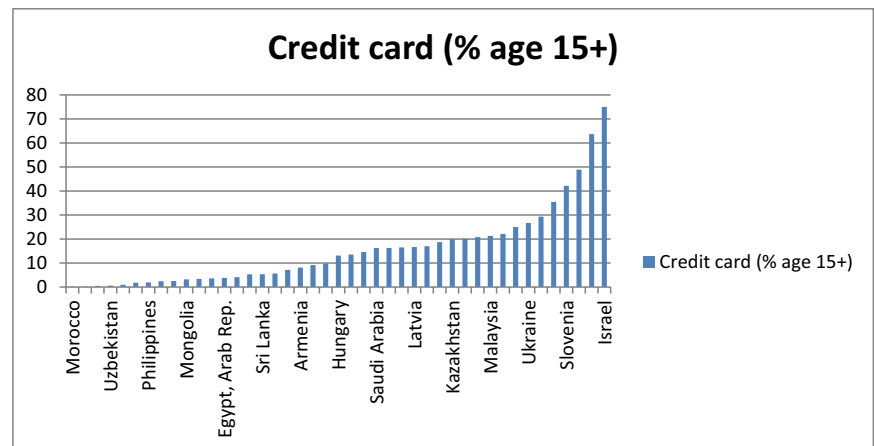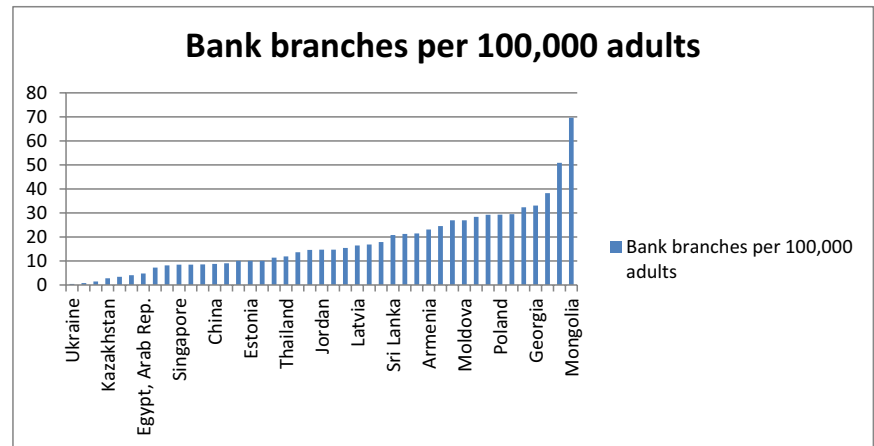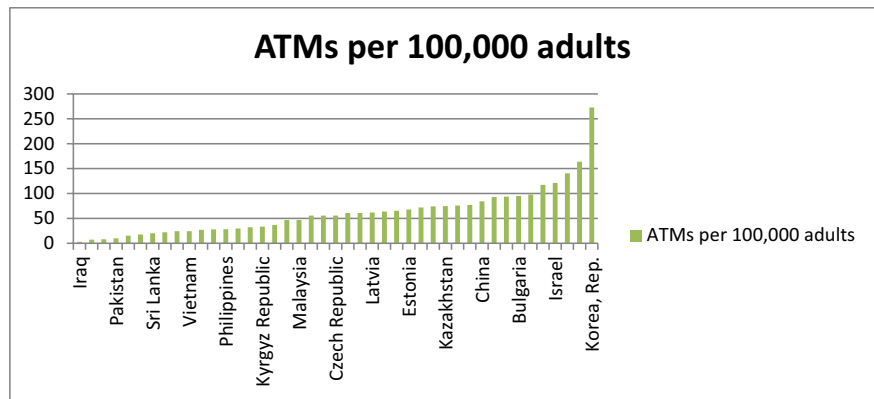**Fig. 1** Financial inclusion indicators of OBOR economies in 2017

Table 3 Descriptive statistics and correlation matrix

	Economic growth	CO2	ATMS	Branches	Credit	Debit	AG	IND	EC	FDI
Descriptive statistics										
Mean	3.82	11.1	53.6	18.6	13.9	38.3	8.69	30.5	79.2	4.12
Std. Dev.	4.26	1.74	49.6	15.3	16.3	27.6	6.55	10.5	18.1	6.69
Min	-5.99	7.76	0.50	-0.73	-1.24	0.99	0.03	-1.15	4.93	-41.5
Max	10.4	16.3	296.0	92.1	79.6	99.2	31.6	66.7	100.0	54.6
Correlation matrix										
Economic growth	1.00									
CO2	0.12*	1.00								
ATMS	0.18*	0.21*	1.00							
Branches	0.13	0.19*	0.25*	1.00						
Credit	0.17*	0.15	0.72*	0.10*	1.00					
Debit	0.18*	0.05	0.56*	0.34*	0.52*	1.00				
AG	0.26*	0.03	-0.50*	-0.10*	-0.59*	-0.57*	1.00			
IND	0.10*	0.30*	-0.41*	-0.26*	-0.38*	-0.18*	-0.07	1.00		
EC	0.01	0.37*	0.01	0.03	-0.01	-0.18*	-0.13*	0.38*	1.00	
FDI	0.15*	-0.15*	-0.04	0.12*	0.06	0.06	-0.09*	-0.05	0.04	1.00

*p value < 0.05

Table 4 Financial inclusion and economic growth (2SLS and GMM)

	2SLS				GMM			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.Economic growth					0.108**	0.079*	0.089**	0.090**
					(0.045)	(0.045)	(0.045)	(0.045)
ATMS	0.020**				0.026**			
	(0.010)				(0.013)			
Branches		0.175				0.221***		
		(0.342)				(0.059)		
Credit			0.067				0.051	
			(0.133)				(0.071)	
Debit				0.013				0.022
				(0.025)				(0.022)
AG	0.150	0.085	0.159	0.152	−0.051	−0.140	−0.085	0.014
	(0.126)	(0.132)	(0.135)	(0.127)	(0.184)	(0.172)	(0.187)	(0.195)
IND	0.248***	0.221***	0.244***	0.251***	0.182**	0.137**	0.107	0.181**
	(0.065)	(0.050)	(0.061)	(0.067)	(0.078)	(0.069)	(0.075)	(0.085)
EC	−0.018	0.059	−0.019	−0.010	−0.054	0.101	−0.056	−0.165**
	(0.054)	(0.162)	(0.054)	(0.056)	(0.086)	(0.096)	(0.083)	(0.078)
FDI	0.093***	0.096***	0.091***	0.090***	0.059*	0.074**	0.068*	0.051
	(0.030)	(0.032)	(0.029)	(0.029)	(0.034)	(0.033)	(0.034)	(0.035)
Constant	−4.542	−5.495	−4.765	−5.165	0.639	−3.883	5.645	9.482
	(5.586)	(6.686)	(5.834)	(6.247)	(7.524)	(7.659)	(7.485)	(7.706)
Observations	559	559	559	559	473	473	473	473
Number of code	43	43	43	43	43	43	43	43
AR (2)					0.785	0.896	0.780	1.023
Sargan test					0.545	0.653	0.321	0.875

Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. GMM approach also uses internal instruments to estimate the panel model; thus, the number of observations reduces

Table 5 Financial inclusion and CO2 emissions (2SLS and GMM)

	2SLS				GMM			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.CO2					0.455***	0.553***	0.501***	0.375***
					(0.043)	(0.0423)	(0.044)	(0.043)
ATMS	0.0067***				0.002***			
	(0.0008)				(0.0003)			
Branches		0.113**				0.002**		
		(0.050)				(0.001)		
Credit			0.043***				0.006***	
			(0.006)				(0.001)	
Debit				0.008***				0.004***
				(0.002)				(0.0005)
AG	−0.024***	−0.065***	−0.018***	−0.023***	−0.014***	−0.017***	−0.015***	−0.008**
	(0.004)	(0.019)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
IND	−0.003	−0.020**	−0.006**	−0.001	−0.002	−0.003**	−0.003	0.0004
	(0.002)	(0.008)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
EC	0.014***	0.064***	0.013***	0.019***	0.010***	0.010***	0.012***	0.013***
	(0.002)	(0.023)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
FDI	0.002**	0.004	0.001	0.0009	0.001**	0.0011	0.001	0.0012**
	(0.001)	(0.004)	(0.001)	(0.001)	(0.0007)	(0.0007)	(0.0007)	(0.0001)
Constant	9.990***	9.376***	9.846***	9.589***	5.357***	4.501***	4.920***	5.799***
	(0.220)	(0.986)	(0.302)	(0.231)	(0.508)	(0.538)	(0.524)	(0.471)
Observations	559	559	559	559	473	473	473	473
Number of code	43	43	43	43	43	43	43	43
AR (2)					0.456	0.750	0.954	0.785
Sargan-test					0.320	0.123	0.863	0.653

Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

value added and FDI have a significant positive effect on economic growth in all four models; however, the effect is insignificant in case of agriculture value added and energy consumption in all four models. The GMM estimates in Table 4 reveal that the lag economic growth remains significantly positive in all four models. The impact of ATMs and bank branches is significantly positive revealing that a 1 percent increase in ATMs and bank branches stimulates economic growth by 0.026 percent and 0.221 percent, respectively. Similar to 2SLS findings, debit cards and credit cards have no significant impact on economic growth.

Our findings infer that financial inclusion improves economic growth by reducing the credit constraints of households and producers. Findings also show that financial inclusion of supply side has only a positive impact on economic growth. This finding is also supported by Chatterjee (2020), who noted that financial inclusion helps inclusive growth by mobilizing savings and investment in the production sector. This suggestion is also backed by Le et al. (2019), who noted that financial expansion is a substantial and tricky fragment of the growth procedure. This means that financial inclusion is a vital instrument of any financial structure and is

necessary to achieve financial development in the economy which helps the economy to grow at a rapid pace. The financial services not only include regular bank services but insurance, pension, saving, and accessibility to other financial products, which has a positive role in economic growth. Financial inclusion improves the economic activity in the society which in turn leads to fostering economic growth. This result is supported by Allen et al. (2014), who suggested that financial inclusion can affect economic growth positively by reducing income inequality and poverty.

Our results are also like the theory argument by Aghion and Bolton (1997), who suggest that easy access to financial services can alter people's decisions about production and employment choices and thus moderate the effects of poverty. Moreover, if the people have easy access to financial services, it will help the people to consume their funds in the formal economy. According to Gopalan and Rajan (2010), if poor people have more access to financial services, they are less vulnerable to the severe impact of poverty. Accordingly, their per capita income and standard of living will improve and thus improve the overall economic growth of the country. Again, industry value added and FDI impact

are significantly positive on economic growth in most cases, but agriculture value added and energy consumption have no association with economic growth as the coefficient estimates are statistically insignificant. The AR (2) statistics are showing that there is no problem of serial correlation in the model, while the Sargan test infers that instrumental variables are also valid.

Table 5 illustrates the empirical evidence of financial inclusion and environmental performance models for 2SLS and GMM techniques. The 2SLS findings reveal that demand-side and supply-side parameters of financial inclusion exert a significant and positive impact on pollution emissions in OBOR economies. The coefficient estimates depict that a 1 percent increase in ATMs brings 0.0067 percent increase in pollution emission, a 1 percent increase in bank branches stimulates 0.113 percent upsurge in pollution emissions, a 1 percent increase in credit cards leads to 0.043 percent rise in pollution emissions, and a 1 percent increase in debit card results in 0.008 percent increase in pollution emissions. Industry value added and agriculture value added have a significant negative impact on pollution emissions in most cases. However, energy consumption has a significant positive impact in all four models, but FDI has a significant positive impact only in case of ATMs model. The findings of GMM model infer that lagged CO_2 emissions remain significantly positive in all four models. Similar to the findings of 2SLS, all the measures of financial inclusion exert a significant positive impact on carbon emissions in OBOR economies. The findings show that a 1 percent rise in ATMs results in increase pollution emissions by 0.002 percent, a 1 percent increase in bank branches leads to 0.002 percent upsurge in carbon emissions, a 1 percent increase in credit cards stimulates pollution emissions by 0.006 percent, and a 1 percent increase of debit cards result in increasing carbon emissions by 0.004 percent.

The results infer that the supply and demand side of financial inclusion is a positive impact on CO_2 emissions. A rising level of financial inclusion can achieve a higher level of economic development without environmental goals. It stated that liquidity, operational, and credit risks are major concerns of financial inclusion (Chen and Sivakumar, 2021; Zhang and Chen, 2020; Lan et al., 2020), while political connected firms have more dynamics performance (Wu et al., 2022). This finding is also supported by Le et al. (2020), who noted that financial inclusion increases the CO_2 emissions in Asian countries. This means that the supply and demand sides of financial inclusion have more potential to increase the financial sector efficiency and boost entrepreneurial industrial activities which result in CO_2 emissions. This also infers that the supply and demand sides of financial inclusion are damaging the environment through dirty energy consumption. These findings are also inconsistent with Zaidi et al. (2021), who noted that financial inclusion

negatively affects the environment by using the channels of green growth in OECD.

The availability of easier financial services has a positive impact on the promotion of manufacturing and industrial activities that could surge the level of CO_2 emissions in the economy and thus contributes to global warming (Gao et al., 2021; Jensen et al. 2010). On the other side, due to easy accessibility to financial services, the consumers will start consuming more energy-intensive products such as cars, refrigerators, freezers, microwaves, and air conditioners that also causing the CO_2 emissions to rise. Lastly, the increased financial inclusion has a multiplier effect on the economy and society that could boost the social and economic activities in the country which in turn may lead to an increase in the demand for non-renewable energy sources and CO_2 emissions. These economic explanations are like Frankel and Romer (1999), Le et al. (2020), and Mehmood (2021). The findings of control variables are also in line with the findings of 2SLS. Results of all four models reveal that agriculture value added and industry value added effect is significantly negative in most cases, and the effect of energy consumption and FDI is significantly positive in most cases. The diagnostics outcomes remain consistent in CO_2 emission models.

Conclusion and policy implications

Financial inclusion is a vital organ in the development of any financial structure and helps the economy to grow. On one side, it is mandatory for the growth of any economy due to the increased availability of financial services and products to the majority of the population in the country. On the other side, due to improved financial inclusion, the consumption and production activities in the economy also increase which causes the energy demand to rise and consequently the CO_2 emissions in the economy rise. Keeping this perspective in mind, we are testing the effect of financial inclusion on the economic-environmental performance of OBOR countries. We have selected four different proxies of financial inclusion, two from the perspective of the supply side and two from the perspective of the demand side. For empirical analysis, we have applied 2SLS and GMM methods.

The findings of the study provided some fruitful information. In the economic growth model, among the variables of financial inclusion, only the variable of ATMS is positively significant when we apply the 2SLS approach and all others are insignificant; however, when we apply the GMM approach, two variables, i.e., ATMS and branches, are positively significant implying that supply-side financial inclusion is vital for economic growth in OBOR countries. On the other side, the variables of financial inclusion, whether supply side or demand side, exerted a positive impact on the

CO_2 emissions irrespective of the estimation technique, i.e., 2SLS or GMM. These findings imply that financial inclusion, in general, causes CO_2 emissions to rise. Few control variables, industrialization, and FDI proved to be important determinants of economic growth, whereas agriculturalization and industrialization proved to be important factors that affect the CO_2 emissions.

These findings have some important implications for the stakeholders. The high pace of economic growth can't be achieved unless financial inclusion is improved from the perspective of supply as well as the demand side. Financial institutions should try to provide funds for the foundation of a green and clean economy that emits carbon in less quantity due to its reliance on renewable energy sources. Financial institutions should try to improve their green credit to the businesses and individuals, on a priority basis, who are more interested in consuming these funds in environmentally friendly projects. This study ignores the transmission channels and effects between financial inclusion and green growth. Future empirical studies can examine the nonlinear impact of financial inclusion on green growth and the environment. The future comparative country-wise empirical analysis will be more helpful in the context of economic and environmental implications.

Declarations

Ethics approval Not applicable

Consent to participate I am free to contact any of the people involved in the research to seek further clarification and information.

Consent for publication Not applicable

Competing interests The authors declare no competing interests.

References

Aghion P, Bolton P (1997) A theory of trickle-down growth and development. Rev Econ Stud 64(2):151–172

Ahmad M, Majeed A, Khan MA, Sohaib M, Shehzad K (2021) Digital financial inclusion and economic growth: provincial data analysis of China. China Economic Journal 1–20

Allen F, Carletti E, Cull R, Qian JQ, Senbet L, Valenzuela P (2014) The African financial development and financial inclusion gaps. J Afr Econ 23(5):614–642

Baulch B, Do TD, Le TH (2018) Constraints to the uptake of solar home systems in Ho Chi Minh City and some proposals for improvement. Renewable Energy 118:245–256

Beck T, Demirgüç-Kunt A, Levine R (2009) Financial institutions and markets across countries and over time-data and analysis. World Bank policy research working paper (4943)

Blundell R, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data models. J Econ 87(1):115–143

Bonnefond C (2014) Growth dynamics and conditional convergence among Chinese provinces: a panel data investigation using system GMM estimator. J Econ Dev 39(4):1–25

Chatterjee A (2020) Financial inclusion, information and communication technology diffusion, and economic growth: a panel data analysis. Inf Technol Dev 26(3):607–635

Chaudhry IS, Yusop Z, Habibullah MS (2021) Financial inclusion-environmental degradation nexus in OIC countries: new evidence from environmental Kuznets curve using DCCE approach. Environmental Science and Pollution Research 1–18

Chen Y, Kumara EK, Sivakumar V (2021) Investigation of finance industry on risk awareness model and digital economic growth. Ann Oper Res. https://doi.org/10.1007/s10479-021-04287-7

Dahiya S, Kumar M (2020) Linkage between financial inclusion and economic growth: an empirical study of the emerging Indian economy. Vision 24(2):184–193

Demirgüç-Kunt A, Singer D (2017) Financial inclusion and inclusive growth: a review of recent empirical evidence. World Bank Policy Research Working Paper (8040)

Emara N, Said El A (2021) Financial inclusion and economic growth: the role of governance in selected MENA countries. Int Rev Econ Financ 75:34–54

Erlando A, Riyanto FD, Masakazu S (2020) Financial inclusion, economic growth, and poverty alleviation: evidence from eastern Indonesia. Heliyon 6(10):e05235

Frankel JA, Romer DH (1999) Does trade cause growth? American Economic Review 89(3):379–399

Gao H, Shi D, Zhao B (2021) Does good luck make people overconfident? Evidence from a natural experiment in the stock market. Journal of Corporate Finance (Amsterdam, Netherlands) 68:101933. https://doi.org/10.1016/j.jcorpfin.2021.101933

Gopalan S, Rajan RS (2010) Financial sector de-regulation in emerging Asia: focus on foreign bank entry. The Journal of World Investment & Trade 11(1):91–108

Jensen D, Webb KA, O'donnell DE (2010) The increased ventilatory response to exercise in pregnancy reflects alterations in the respiratory control systems ventilatory recruitment threshold for CO_2. Respir Physiol Neurobiol 171(2):75–82

Kim DW, Yu JS, Hassan MK (2018) Financial inclusion and economic growth in OIC countries. Res Int Bus Financ 43:1–14

Kim JH (2016) A study on the effect of financial inclusion on the relationship between income inequality and economic growth. Emerg Mark Financ Trade 52(2):498–512

Lan G, Lv Y, Kuang X, Wu Y (2020) Effect of China coastal aera's income distribution based on the network financial environment. J Coastal Res 103(sp1):246-251. https://doi.org/10.2112/SI103-053.1

Le TH, Chuc AT, Taghizadeh-Hesary F (2019) Financial inclusion and its impact on financial efficiency and sustainability: empirical evidence from Asia. Borsa Istanbul Rev 19(4):310–322

Le TH, Le HC, Taghizadeh-Hesary F (2020) Does financial inclusion impact CO_2 emissions? Evidence from Asia. Finance Research Letters 34:101451

Li L (2018) Financial inclusion and poverty: the role of relative income. China Econ Rev 52:165–191

Li X, Ozturk I, Majeed MT, Hafeez M, Ullah S (2022) Considering the asymmetric effect of financial deepening on environmental quality in BRICS economies: policy options for the green economy. Journal of Cleaner Production 331:129909

Liu N, Hong C, Sohail MT (2021) Does financial inclusion and education limit CO2 emissions in China? A new perspective. Environmental Science and Pollution Research 1–8

Makina D, Walle YM (2019) Financial inclusion and economic growth: evidence from a panel of selected african countries. In Extending Financial Inclusion in Africa (pp. 193–210). Academic Press

Mehmood U (2021) Examining the role of financial inclusion towards CO2 emissions: presenting the role of renewable energy and globalization in the context of EKC. Environ Sci Pollut Res 1–9

Mushtaq R, Bruneau C (2019) Microfinance, financial inclusion and ICT: implications for poverty and inequality. Technology in Society 59:101154

Ozili PK (2020) Theories of financial inclusion. In Uncertainty and Challenges in Contemporary Economic Behaviour. Emerald Publishing Limited

Park CY, Mercado R (2018) Financial inclusion, poverty, and income inequality. The Singapore Economic Review 63(01):185–206

Pradhan RP, Arvin MB, Nair MS, Hall JH, Bennett SE (2021) Sustainable economic development in India: the dynamics between financial inclusion, ICT development, and economic growth. Technological Forecasting and Social Change 169:120758

Qin L, Raheem S, Murshed M, Miao X, Khan Z, Kirikkaleli D (2021) Does financial inclusion limit carbon dioxide emissions? Analyzing the role of globalization and renewable electricity output. Sustain Dev 29:1138–1154

Raheem ID, Tiwari AK, Balsalobre-Lorente D (2020) The role of ICT and financial development in CO 2 emissions and economic growth. Environ Sci Pollut Res 27(2):1912–1922

Rahim N, Wan K, Franceschelli M (2009) Financial inclusion amongst new migrants in Northern Ireland: a literature review Information Centre about Asylum and Refugees London

Renzhi N, Baek YJ (2020) Can financial inclusion be an effective mitigation measure? Evidence from panel data analysis of the environmental Kuznets curve. Finance Research Letters 37:101725

Sarma M, Pais J (2011) Financial inclusion and development. J Int Dev 23(5):613–628

Sethi D, Acharya D (2018) Financial inclusion and economic growth linkage: some cross country evidence. Journal of Financial Economic Policy 10(3):369–385

Sharma D (2016a) Nexus between financial inclusion and economic growth: evidence from the emerging Indian economy. Journal of Financial Economic Policy 8(1):13–36

Sharma D (2016b) Nexus between financial inclusion and economic growth. Policy 8(1):13–36

Singh D, Stakic N (2021) Financial inclusion and economic growth nexus: evidence from SAARC countries. South Asia Res 41(2):238–258

Swamy V (2014) Financial inclusion, gender dimension, and economic impact on poor households. World Dev 56:1–15

Ullah S, Ozturk I, Majeed MT, Ahmad W (2021) Do technological innovations have symmetric or asymmetric effects on environmental quality? Evidence from Pakistan. Journal of Cleaner Production 316:128239

Usman A, Ozturk I, Ullah S, Hassan A (2021) Does ICT have symmetric or asymmetric effects on CO2 emissions? Evidence from selected Asian economies. Technology in Society 67:101692

Van LTH, Vo AT, Nguyen NT, Vo DH (2021) Financial inclusion and economic growth: an international evidence. Emerg Mark Financ Trade 57(1):239–263

Wooldridge JM (2010) Econometric analysis of cross section and panel data. MIT press

Wu B, Liang H, Chan S (2022) Political connections, industry entry choice and performance volatility: evidence from China. Emerg Mark Financ Trade 58(1):290–299. https://doi.org/10.1080/1540496X.2021.1904878

Xie H, Chang HL, Hafeez M, Saliba C (2021) COVID-19 post-implications for sustainable banking sector performance: evidence from emerging Asian economies. Economic Research-Ekonomska Istraživanja 1–16

Yang L, Hui P, Yasmeen R, Ullah S, Hafeez M (2020) Energy consumption and financial development indicators nexuses in Asian economies: a dynamic seemingly unrelated regression approach. Environ Sci Pollut Res 27(14):16472–16483

Zaidi SAH, Hussain M, Zaman QU (2021) Dynamic linkages between financial inclusion and carbon emissions: evidence from selected OECD countries. Resources, Environment and Sustainability 4:100022

Zhang H, Chen Z (2020) Design of risk guarantee platform for financial support of port logistics industry. J Coastal Res 103(sp1):749–752. https://doi.org/10.2112/SI103-154.1

Zhao H, Yang Y, Li N, Liu D, Li H (2021) How does digital finance affect carbon emissions? Evidence from an Emerging Market Sustainability 13(21):12303

Zhao W, Hafeez M, Maqbool A, Ullah S, Sohail S (2021) Analysis of income inequality and environmental pollution in BRICS using fresh asymmetric approach. Environmental Science and Pollution Research 1–11