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 CO2 emissions irrespective of the estimation techniques, i.e., 2SLS and GMM. These findings imply that financial inclusion, in general, causes CO2 emissions to rise.

Keywords Financial inclusion · GDP · CO2 emissions

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 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 contributed 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 CO2 emissions, due to the unavailability of data on financial inclusion. However, several studies have reported the impact of financial development on CO2 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 CO2 emissions is still puzzling, but the direction is clear among financial inclusion and economic growth. Henceforth, the breakup of financial inclusion into 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 intracountry 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 CO2 emissions and hence can be written as:

\[
\text{Economic growth}_{it} = \beta_0 + \beta_1 \text{FIS}_{it} + \beta_2 \text{FDI}_{it} + \beta_3 \text{IND}_{it} + \beta_4 \text{AG}_{it} + \beta_5 \text{EC}_{it} + \beta_6 \text{FDI}_{it} + \epsilon_{it}
\]  

(1)

\[
\text{CO}_2_{it} = \beta_{10} + \beta_{11} \text{FIS}_{it} + \beta_{12} \text{FDI}_{it} + \beta_{13} \text{IND}_{it} + \beta_{14} \text{AG}_{it} + \beta_{15} \text{EC}_{it} + \beta_{16} \text{FDI}_{it} + \epsilon_{it}
\]  

(2)

In the above models (1 and 2), the Economic growth represents economic growth and CO2 is CO2 emissions of country (i) in period (t). FIS is financial inclusion supply side and FDI is financial inclusion demand side of country 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...
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:

\[
\text{Economic growth}_{it} = \beta_0 + \delta_1 \cdot \text{Economic growth}_{it-1} + \beta_1 \cdot \text{FIS}_{it} + \beta_2 \cdot \text{FID}_{it} + \beta_3 \cdot \text{IND}_{it} + \beta_4 \cdot \text{AG}_{it} + \beta_5 \cdot \text{EC}_{it} + \beta_6 \cdot \text{FDI}_{it} + \epsilon_{it}
\]

\[
\text{CO}_2_{it} = \beta_0 + \delta_1 \cdot \text{CO}_2_{it-1} + \beta_1 \cdot \text{FIS}_{it} + \beta_2 \cdot \text{FID}_{it} + \beta_3 \cdot \text{IND}_{it} + \beta_4 \cdot \text{AG}_{it} + \beta_5 \cdot \text{EC}_{it} + \beta_6 \cdot \text{FDI}_{it} + \epsilon_{it}
\]

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

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**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|
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. CO2 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 card-holders 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, CO2, 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    |
| CO2 emissions                            | CO2      | CO2 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 |
|-----------------|-----|------|----------|--------|-------|----|-----|----|-----|
| **Mean**        | 3.82| 11.1 | 53.6     | 18.6   | 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| 6.69|
| **Min**         | -5.99| 7.76 | 0.50     | -0.73  | -1.24 | 0.99| 0.03| -1.15| 4.93|
| **Max**         | 10.4| 16.3 | 296.0    | 92.1   | 79.6  | 99.2| 31.6| 66.7| 100.0|

*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|

*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** |
| ATMS     | 0.020** | 0.026** |     |     |     |     |     |
| Branches | 0.017 | 0.067 | 0.221*** |     |     |
| Credit   | 0.150 |  0.126 | (0.135) |     |     |
| Debit    | 0.126 |  0.132 | (0.135) | 0.152 | (0.127) | 0.184 | (0.172) | 0.187 | (0.195) |     |     |
| AG       | 0.248*** | 0.221*** | 0.244*** | 0.251*** | 0.182** | 0.137** | 0.107 | 0.181** |     |     |
| IND      | -0.018 |  0.054 | (0.162) | 0.059 | (0.054) | 0.056 | (0.086) | 0.096 | (0.083) | 0.078 |     |
| EC       | 0.093*** | 0.096*** | 0.091*** | 0.090*** | 0.059* | 0.074** | 0.068* | 0.051 |     |     |
| FDI      | -4.542 | -5.495 | -4.765 | -5.165 | 0.639 | -3.883 | 5.645 | 9.482 |     |     |
| Constant | 559 | 559 | 559 | 559 | 473 | 473 | 473 | 473 |     |     |
| Observations | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |     |     |
| Number of code | 0.785 | 0.896 | 0.780 | 1.023 | 0.875 |     |     |     |     |
| AR (2)   | 0.045 | (0.054) | 0.045 | (0.045) | 0.045 |     |     |     |     |
| 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.
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

| 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**         | 0.098***        | 0.008***        | 0.006**         |                 |                 |                 |                 |
|                 | (0.050)         | (0.006)         | (0.002)         | (0.01)          |                 |                 |                 |                 |
| Credit          |                 | 0.043***        |                 |                 | 0.017***        | 0.017***        | 0.015***        | 0.008**         |
|                 |                 | (0.006)         |                 |                 | (0.001)         | (0.001)         | (0.001)         | (0.0005)        |
| Debit           |                 |                 |                 |                 | 0.014***        | 0.013***        | 0.019***        | 0.013***        |
|                 |                 |                 |                 |                 | (0.002)         | (0.002)         | (0.002)         | (0.001)         |
| AG              | −0.024***       | −0.065***       | −0.018***       | −0.023***       | −0.014***       | −0.017***       | −0.015***       | −0.008**        |
|                 | (0.004)         | (0.006)         | (0.004)         | (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)         | (0.01)          |
| 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
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 CO2 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 CO2 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 CO2 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 CO2 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 CO2 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 CO2 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 CO2 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 CO2 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 CO2 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
CO2 emissions irrespective of the estimation technique, i.e., 2SLS or GMM. These findings imply that financial inclusion, in general, causes CO2 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 CO2 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.

**Author contribution** This idea was given by Liu Dong and Muhammad Hafeez. Yuying Zhang, Muhammad Hafeez, Liu Dong, and Sana Ullah collected the data, computed data analysis, and wrote the complete paper, while Liu Dong and Sana Ullah read and approved the final version.

**Data availability** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**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.

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