Finance Research Letters 34 (2020) 101451

Contents lists available at ScienceDirect

Finance Research Letters

journal homepage: www.elsevier.com/locate/frl

Does financial inclusion impact CO_2 emissions? Evidence from Asia

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A R T I C L E I N F O

JEL classification:
O16
O57
C33

Keywords:
Financial inclusion
Climate change
CO_2 emissions
Panel data analysis
Asia

A B S T R A C T

This study examines the impact of financial inclusion on CO_2 emissions using a sample of 31 Asian countries during the period 2004–2014. Three composite indicators for financial inclusion are constructed using principal component analysis (PCA) based on normalized variables. To estimate the model, we adopted the Hoechle (2007) procedure which produces Driscoll-Kraay standard errors for linear panel models that are not only heteroskedasticity consistent but also robust to general forms of cross-sectional dependence. We find that income, energy consumption, industrialization, urbanization, FDI and financial inclusion appear to have led to higher emissions of CO_2 in the region. Meanwhile, increased openness to trade seems to have reduced CO_2 emissions. The findings are qualitatively robust to different proxies of financial inclusions and reasonable modifications to specification of the model. The empirical results imply that there are currently no policy synergies between growing financial inclusion and mitigating CO_2 emissions. Thus, financial inclusion should be integrated into climate change adaptation strategies at local, national and regional levels, especially to address the side effect of higher CO_2 emissions associated with improved financial inclusion.

1. Introduction

Financial development is a significant and inextricable part of the growth process (Le et al., 2019a). Financial inclusion is an integral dimension of financial development; it contributes to fostering the development of financial sectors and institutions. The concept of financial inclusion has emerged since the early 2000s, arising from a study that considered financial exclusion as a major cause of poverty (Chibba, 2009). According to World Bank (2018), financial inclusion implies that all individuals and businesses have access to a range of financial products and services, such as transactions, payments, savings, credit and insurance, to meet their needs in an affordable, convenient, responsible and sustainable manner.

This study examines the impact of financial inclusion on climate change. While the effects of financial development on CO_2 emissions have been documented in many studies (for instance, Sadorsky (2010) for emerging economies; Zhang (2011) for China; Shahbaz et al. (2013) for Malaysia; Boutabba (2014) for India; Farhani and Ozturk (2015) for Tunisia; Charfeddine and Kahia (2019) for MENA countries), the number of studies that considers the role of financial inclusion in combating climate change is extremely scarce, due to the unavailability of financial inclusion index data.

In theory, the effects of financial inclusion on CO_2 emissions could be both negative and positive. On one hand, financial inclusion grants easier access to useful and affordable financial schemes to businesses and individuals, which make investments in green technology more feasible. In this regard, inclusive financial systems bring favorable impacts on the environment as a mechanism to

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https://doi.org/10.1016/j.frl.2020.101451
Received 20 December 2019; Received in revised form 3 January 2020; Accepted 30 January 2020
Available online 31 January 2020
1544-6123/

increase the accessibility, affordability, and adoption of better environmental practices that reduce contributions to climate change (IPA, 2017). Promoting financial inclusion is particularly relevant for poor communities where farmers may not have capital or credit available to invest in clean energy technology, such as solar energy microgrids, which is not only cost effective but also produces much less CO_2 emissions than burning coal (IPA, 2017). Financial constraints (limited access to capital, lack of financial support from the government and financing options from banks) are also identified as significant barriers to the take-up of solar home systems in Ho Chi Minh City (Vietnam) (Baulch et al., 2018). These are typical examples in which the availability of affordable financial products and services can help promote the use of clean technologies and the adoption of environmentally protective services, which reduce CO_2 emissions by burning fewer fossil fuels.

On the other hand, improved access to the financial services aids and boosts manufacturing and industrial activities which may lead to higher level of CO_2 emissions that, in turn, increases global warming (Jensen, 1996). Furthermore, higher financial inclusion enables consumers to afford energy-intensive consumer goods such as automobiles, refrigerators and air-conditioners, whose uses present a serious threat to the environment since more greenhouse gases (GHG) are emitted. Inclusive financial systems also foster economic activities, and thereby raise the demand for polluting energy sources, which increases GHG emissions (Frankel and Romer, 1999).

This study examines the impact of financial inclusion - a critical feature of financial development, on GHG emissions. Asia is chosen as our case study due to the significant relevance of this theme (regarding both financial inclusion and climate change) to the region. Specifically, we examine whether the provision of proper financial services to all citizens of age, including the most vulnerable communities of society, contributes to mitigating GHG emissions in the region.

Asia is the world's most dynamic region with fastest-growing economies. Despite achieving significant progress in financial inclusion, financial exclusion remains a critical challenge to the region. Almost more than one billion people have no access to formal financial services; they have no formal employment, no bank account, no significant ability to participate in the online and offline paid work activities (Bhardwaj et al., 2018). Moreover, only about 27% of adults within developing Asian countries reportedly have an account at a formal financial institution, while only around one third of firms have loans or lines of credit, which are the most common types of external financing (Bhardwaj et al., 2018). Since there are substantial across-country and intra-country disparities in the region, a holistic approach to promote financial inclusion is likely to be a feasible solution for Asia (IMF, 2018).

Home to two-thirds of the world's poor, Asia is also considered one of the most vulnerable areas to the impacts of climate change (Asian Development Bank (ADB), 2017). Fig. 1 illustrates that Asia is the biggest CO_2 emitter of the world over the last decade, contributing to almost one third of all global emissions. Countries in Asia are put at high risk and it would be disastrous if the mitigation and adaptation efforts were not carried out vigorously and quickly.

The rest of this study is organized as follows. Section 2 presents the baseline model, data and methodologies. Section 3 discusses the empirical results. Section 4 concludes the study.

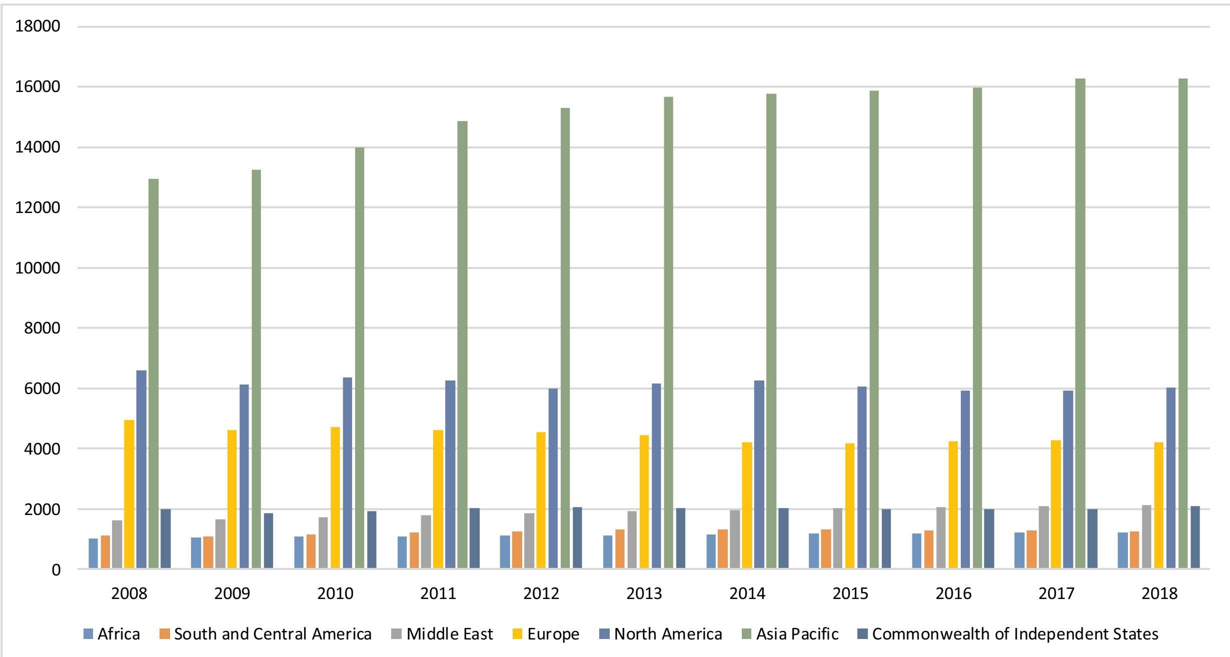

Fig. 1. World carbon dioxide emissions: 2008–2018, by region (in million metric tons of carbon dioxide).
Source: Authors' work. Data are taken from Satista (https://www.statista.com/statistics/205966/world-carbon-dioxide-emissions-by-region/).

2. Data and methodologies

This study examines the roles of financial inclusion in reducing greenhouse gas emissions to prevent climate change in Asia. To get a start, we adopt a theoretical and analytical framework that extends the "Stochastic Impacts by Regression on Population, Affluence and Technology" ("STIRPAT") model proposed by Dietz and Rosa (1997), as follows.

$$I_{it} = \alpha_{it} P_{it}^{\beta_1} A_{it}^{\beta_2} T_{it}^{\beta_3} \varepsilon_{it} \tag{1}$$

where I represents the environmental effects (I) of human aspects and activities including population (P), affluence (A) and technology (T), for country i at time t. α represents the country specific effect. β_1, β_2, and β_3 are the elasticities of environmental effects (proxied by GHG emissions) with respect to P, A and T, respectively. The variables in model (1) are converted into logarithmic form as follows:

$$lnI_{it} = \alpha_{it} + \beta_1 lnP_{it} + \beta_2 lnA_{it} + \beta_3 lnT_{it} + \varepsilon_{it} \tag{2}$$

Besides financial inclusion, this study extends the basic STIRPAT model in (2) by considering a number of additional control variables that have also been identified to have effects on emissions by the current literature, namely, urbanization (Cole and Neumayer, 2004; Zhou et al., 2013; Sadorsky, 2013, 2014; Xu and Lin, 2015; Ali et al., 2016; Sinha et al., 2017), industrialization (Zhou et al., 2013), trade openness (Ozturk and Acaravci, 2013; Ali et al., 2016; Sinha et al., 2017), and FDI (Zhang and Zhou, 2016). In addition, based on the model in Eq. (2) as an aggregate model, this study takes the per capita forms by dividing both sides of the equation by total population. Apart from FDI, all the variables are taken logarithms.[1] The baseline model of this study is thus following.

$$\begin{aligned} lnGHG_{i,t} = {} & \beta_0 + \beta_1 \times lnINC_{i,t} + \beta_2 \times lnENE_{i,t} + \beta_3 \times FDI_{i,t} + \beta_4 \times lnTRADE_{i,t} + \beta_5 \times lnURB_{i,t} + \beta_6 \times lnFIN_{i,t} + \beta_7 \times lnIND_{i,t} \\ & + \varepsilon_{i,t} \end{aligned} \tag{3}$$

The dependent variable, GHG, is greenhouse gas emissions, proxied by CO_2 emissions. Without rapid reductions in CO_2 emissions, climate change will increasingly cause irreversible devastating effects on life on earth. The independent variables, INC, ENE, FDI, TRADE, URB, and IND refer to income, energy intensity, foreign direct investment, trade openness, urbanization, and industrialization, respectively. The data are taken from World Development Indicators (WDI) on an annual basis.

The most important regressor is financial inclusion. To construct this variable, we develop a composite Financial Inclusion Index that considers five aspects of financial inclusion. The data are taken from the World Bank's Global Financial Development Database (GFDD). Subject to data availability, we have in total 31 countries for our study sample for the investigation period 2004–2014. Table 1 describes the variables and data sources.

Table 1 indicates that the financial inclusion indicators have different units and scales. Furthermore, some variables have a high variance while some has a low one. It is thus necessary to transform these indicators to normalized variables before aggregating them to form a composite index (Le et al., 2019b). Principal component analysis (PCA) is then performed on the normalized variables.[2] For comparison and robustness check, we employ different methods of normalization, namely, z-score, min-max and softmax techniques and thus construct three proxies for our financial inclusion variable accordingly.[3]

Prior to estimation, two different assumptions about the error process, i.e. serial correlation and heteroscedasticity were tested, respectively, using Wooldridge (2002) test and Modified Wald test. The results in Table 2 confirm the existence of serial correlation and heteroscedasticity at 1 percent level. Furthermore, the results in Table 3 indicate the presence of cross-sectional dependence under a fixed effect specification.

As such, the study estimates the models using the robust standard errors proposed by Driscoll and Kraay (1998) for panel regressions with cross-sectional dependence (SCC). Specifically, we adopted the xtscc program developed by Hoechle (2007) which produces Driscoll and Kraay (1998) standard errors for linear panel models since they are not only heteroskedasticity consistent but also robust to very general forms of cross-sectional and temporal dependence (Le and Tran-Nam, 2018). Furthermore, the xtscc program works well with both balanced and unbalanced panels, which is the case of this study. It can handle missing values (Hoechle, 2007). For comparison and completeness, we estimate Driscoll and Kraay (1998) standard errors for coefficients by pooled Ordinary Least Squares/Weighted Least Squares, fixed-effects (within), and Generalized Least Squares random effects regressions.

3. Results and discussion

The estimation results by performing Hoechle (2007)'s procedure are reported in Table 4. The results show that apart from trade openness, increases in the remaining explanatory variables, namely, income, energy consumption, urbanization, FDI, industrialization and financial inclusion contribute to higher level of carbon emissions in Asia.

[1] This study does not use logarithms for FDI to avoid causing missing values since many FDI values are negative.

[2] Two tests, Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) test, were performed at the beginning of the PCA in order to examine the suitability of these data for factor analysis. The results of both tests support the use of PCA in this study. The results are not presented here to conserve space, but they are available upon request.

[3] Please refer to (Le et al 2019b) for the technical details of these normalization techniques and PCA. The details are not presented here to conserve space.

Table 1
Variable definitions, data sources, and statistical descriptions (31 countries): 2004–2014.

Variable	Description	Source	Obs	Mean	Std. Dev.	Min	Max
INC	GDP per capita (constant 2010 US$)	WDI	341	15,029.67	19,236.44	333.2167	71,992.03
POPG	Population growth (annual%)	WDI	341	2.481434	2.665431	−0.18523	17.51095
URB	Urban population (% of total population)	WDI	341	58.73833	27.79677	18.196	100
ENE	Energy intensity level of primary energy (MJ/$2011 PPP GDP)	WDI	341	5.135575	2.397524	0.426175	16.83079
IND	Industry (including construction), value added (% of GDP)	WDI	328	34.49873	15.87794	3.719908	74.8123
TRADE	Trade (% of GDP)	WDI	339	105.0535	64.59446	23.92236	437.3267
FDI	Foreign direct investment, net inflows (% of GDP)	WDI	341	4.85829	5.878899	−4.33687	43.91211
CO2	CO2 emissions (metric tons per capita)	WDI	341	7.510679	10.45789	0.03841	62.06618
FI1	Automated Teller Machines (ATMs) per 100,000 adults	GFDD	324	43.37918	54.75954	0.011974	288.6319
FI2	Branches of commercial banks per 100,000 adults	GFDD	332	14.25178	11.8718	0.373647	71.60711
FI3	Institutions of commercial banks	GFDD	340	43.15294	43.37237	3	296
FI4	Outstanding deposits with commercial banks (% of GDP)	GFDD	334	62.30782	46.88476	3.600602	249.5537
FI5	Outstanding loans with commercial banks (% of GDP)	GFDD	334	47.37856	30.52209	1.162327	155.5139

Note: Data Source: WDI: World Development Indicators; GFDD: World Bank's Global Financial Development Database. Note that the data for Financial Inclusion (financial access indicators) from GFDD only starts from 2004 to 2016 while the latest data for CO2 emissions from WDI is only until 2014. Thus, the investigation period spans from 2004 to 2014. The study sample include 31 countries, namely, Afghanistan, Brunei, Tajikistan, Yemen, Bangladesh, Bhutan, Cambodia, India, Indonesia, Kyrgyz Republic, Mongolia, Pakistan, Philippines, Sri Lanka, Vietnam, Israel, Japan, South Korea, Kuwait, Macao, Qatar, Saudi Arabia, Singapore, United Arab Emirates, Iraq, Jordan, Kazakhstan, Lebanon, Malaysia, Maldives, Thailand. Source: Authors' calculations.

Table 2
Results of diagnostic tests for heteroscedasticity and serial correlation.

Test	Error process	Test statistic FI_Z	FI_MMX	FI_SOFTMAX
Modified Wald (χ^2)	Heteroscedasticity	14,533.61***	11,505.61***	13,207.81***
Wooldridge Test (*F*-test)	Serial correlation	23.838***	23.711***	24.121***

Notes: LM = Lagrange Multiplier. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$. Heteroscedasticity: Modified Wald test for group-wise heteroscedasticity in fixed effect regression model; H0: sigma(i)^2 = sigma^2 for all i: No heteroscedasticity. Serial correlation: Wooldridge test for autocorrelation in panel data; H0: No first-order autocorrelation. FI_Z, FI_MMX and FI_SOFTMAX denote composite financial inclusion index constructed by performing principal component analysis (PCA) on financial indicators normalized by z-score, min-max and softmax techniques, respectively. Source: Authors' calculations.

Table 3
Pesaran (2004) CD test for cross-section independence in macro panel data.

Variable	CD-test statistic	*p*-value
INC	32.353***	0.000
URB	43.962***	0.000
ENE	9.672***	0.000
IND	9.318***	0.000
TRADE	9.875***	0.000
FDI	4.279***	0.000
CO2	10.748***	0.000
FI_Z	26.991***	0.000
FI_MMX	28.856***	0.000
FI_SOFTMAX	27.663***	0.000

Notes: Under the null hypothesis of cross-section independence, CD ~ N(0,1). *p*-values close to zero indicate data are correlated across panel groups.

*** Indicates rejection of the null hypothesis at the 1% significance level. FI_Z, FI_MMX and FI_SOFTMAX denote composite financial inclusion index constructed by performing PCA on financial indicators normalized by *z*-score, min-max and softmax techniques, respectively. Source: Authors' calculations.

The positive impacts of income on emissions imply that as countries across Asia develop, the level of carbon emissions worsens. This finding is consistent with Le and Quah (2018) where economic growth does not necessarily presume sustainable development that aims to improve the environmental quality in the region. The use of eco-friendly technologies is seemingly ignored in the growth processes of countries in Asia.

The positive effects of energy consumption, urbanization, and industrialization on carbon emissions are also expected and in line with other studies (for instance, Le and Quah, 2018; Saboori et al., 2017). Thanks to remarkable economic growth, the regional

Table 4
Estimation results: Driscoll-Kraay standard errors.

Dept variable: CO2	Pooled OLS/WLS regression			Fixed effects (within) regression			GLS random effects regression		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
INC	0.634***	0.629***	0.634***	1.181***	1.151***	1.178***	0.913***	0.892***	0.913***
	[0.010]	[0.010]	[0.010]	[0.071]	[0.071]	[0.071]	[0.026]	[0.027]	[0.026]
ENE	0.652***	0.653***	0.651***	1.118***	1.117***	1.117***	1.039***	1.041***	1.039***
	[0.047]	[0.051]	[0.048]	[0.041]	[0.042]	[0.041]	[0.060]	[0.061]	[0.060]
URB	0.697***	0.710***	0.697***	0.551***	0.486***	0.530***	0.321**	0.312***	0.308**
	[0.021]	[0.023]	[0.021]	[0.103]	[0.108]	[0.105]	[0.105]	[0.092]	[0.100]
TRADE	−0.087***	−0.104***	−0.089***	−0.106**	−0.105**	−0.106**	−0.140*	−0.134*	−0.138*
	[0.026]	[0.026]	[0.027]	[0.038]	[0.040]	[0.039]	[0.069]	[0.067]	[0.070]
FDI	0.013**	0.013**	0.013**	0.001	0.001	0.001	0.002	0.002	0.002
	[0.005]	[0.005]	[0.005]	[0.003]	[0.003]	[0.003]	[0.002]	[0.002]	[0.003]
IND	0.412***	0.414***	0.413***	0.209***	0.205***	0.211***	0.139***	0.140***	0.142***
	[0.041]	[0.041]	[0.041]	[0.053]	[0.050]	[0.052]	[0.032]	[0.028]	[0.031]
FI_Z	0.064*			0.023***			0.041***		
	[0.033]			[0.006]			[0.006]		
FI_MMX		0.244**			0.082***			0.133***	
		[0.101]			[0.017]			[0.017]	
FI_SOFTMAX			0.298*			0.107***			0.186***
			[0.150]			[0.026]			[0.026]
CONST	−9.180***	−9.376***	−9.493***	−13.149***	−12.716***	−13.168***	−9.432***	−9.396***	−9.600***
	[0.074]	[0.110]	[0.170]	[0.938]	[0.940]	[0.920]	[0.635]	[0.581]	[0.622]
Observations	301	301	301	301	301	301	301	301	301
Number of groups	31	31	31	31	31	31	31	31	31

Note: Standard errors are reported in brackets.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
OLS/WLS: Ordinary Least Squares/Weighted Least Squares. GLS: Generalized Least Squares. Driscoll and Kraay (1998) standard errors for coefficients were estimated by pooled Ordinary Least Squares/Weighted Least Squares, fixed-effects (within), and Generalized Least Squares random effects regressions. FI_Z, FI_MMX and FI_SOFTMAX denote composite financial inclusion index constructed by performing PCA on financial indicators normalized by z-score, min-max and softmax techniques, respectively. Source: Authors' calculations.

energy demand contributes to around 30% of the global demand and is on the rise in the decades to come. The rising demand and thirst for energy in Asia is the aftermath of the outbreak economic boom, rising urbanization and industrialization. The rapid industrialization and urbanization process in many countries across Asia has raised energy demand for industries, such as manufacturing, transportation, electricity, heating and residential sectors. According to Southeast Asia Energy Outlook (2019), fossil fuels are forecasted to account for nearly 80% of the rise in primary energy consumption in Asia through 2035; this is expected to drive up the regional CO_2 emissions by about 65% by that period.

The unfavorable influences of FDI on CO_2 emissions could be explained by foreign investors' intention to avoid stringent environmental regulations in their home countries. In this case, the FDI sector would create negative impacts on the sustainable development of Vietnam, leading to severe consequences for the ecosystem and reduced the sustainability of economic growth in the recipient country. Overall, this result seems to support the pollution haven hypothesis that dirtier industries have been shifting from the developed to the developing world to escape tighter environmental standards (Le et al., 2016).

Interestingly, openness to trade seems to reduce CO_2 emissions in Asia. In fact, trade agreements can enhance the capacity for governments to tackle environmental issues (Le et al., 2016). Specifically, the reduction or elimination of trade barriers to environmental goods and services can facilitate the adoption of eco-friendly technologies at a lower cost. For instance, by providing access to green goods, services, and investments, the Trans-Pacific Partnership (TPP) agreement is expected to assist developing countries to shift into cleaner, less-polluting industries as well as transit to low-carbon pathways, thereby supporting efforts to address global issues like climate change (Meltzer, 2014).

Our key variable of interest, financial inclusion, appears to have led to higher CO_2 emissions in Asia. This result suggests that during the investigation period, with improved access to finance, citizens in Asia could afford to buy more big-ticket items such as automobiles, refrigerators, air-conditioners, and television sets, whose widespread uses accelerate the national use of energy from fossil fuels and result in higher CO_2 emissions in the region.

Our finding indicates that there have not been synergies between financial inclusion initiatives with climate change policies. The results are qualitatively robust to different proxies of financial inclusion and relatively robust to different regression models with Driscoll and Kraay standard errors (apart from the statistical significance of FDI coefficients).

4. Conclusions

This study finds that, during the period 2004–2014, most of the considered factors (income, energy consumption, urbanization, industrialization, FDI and financial inclusion) appear to have led to higher CO_2 emissions in Asia while increased trade openness seems to have reduced emissions. The finding on the negative environmental effects of financial inclusion certainly does not imply that we should reduce financial inclusion. Instead, policymakers should facilitate financial inclusion and access to finance in a more accurate direction. For instance, China is the key player of green finance which clearly has paramount policy importance (Zhang et al., 2019). The “Green Credit Guidelines” announced in February 24, 2012, was regarded as a milestone in China's green credit policy, under which Chinese financial institutions need to provide support for the development of a green, low-carbon economy, improve their standard of green credit financial services, and enhance the debt-supporting capacity of green credit (Liu et al., 2019). Green credit guarantee scheme is expected to reduce the risk of green finance (Taghizadeh-Hesary and Yoshino, 2019).

Efforts need to be made across countries in the region to align financial inclusion initiatives with environmental policies. Europe has been the most active promoter of international climate change cooperation (Zhang et al., 2019). Despite substantial political and ideological conflicts, European governments introduced the European Emission Trading Scheme (EU-ETS) in 2005, following the ratification of the Kyoto protocol (Mazza and Petitjean, 2015).

Policymakers need to expand access to, and inclusiveness of, climate finance to help disadvantaged and economically marginalized segments of society cope with rising CO_2 emissions. Individuals, micro-, small-and medium sized enterprises should be given proper access to financial products and services to enable them to take local, small-scale mitigation and adaptation actions toward reducing CO_2 emissions. In this regard, Sachs et al. (2019) note the importance of the enormous public and private investment for the transition to a low-carbon, green economy, among other Sustainable Development Goals.

CRediT authorship contribution statement

Thai-Ha Le: Conceptualization, Formal analysis, Investigation, Methodology, Writing - original draft, Writing - review & editing. **Ha-Chi Le:** Data curation, Formal analysis, Writing - original draft. **Farhad Taghizadeh-Hesary:** Writing - review & editing.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.frl.2020.101451.

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