



Financial inclusion, renewable energy consumption, and inclusive growth: cross-country evidence

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Abstract The COVID-19 pandemic has affected the global economy to varying degrees. Coupled with the widening gap caused by the unbalanced distribution of resources, the sustainability and inclusiveness of economic growth have been challenged. To explore the influencing factors of the level of economic inclusive growth among different countries, we used the spatial Durbin model to analyze the relationship between financial inclusion, renewable energy consumption, and inclusive growth based on panel data of 40 countries from 2010 to 2020. The results indicate a spatial autocorrelation in inclusive growth; financial inclusion and renewable energy consumption both contributed positively to inclusive growth, while industrial structure upgrading played a negative moderating role between domestic renewable energy consumption and inclusive growth. The results of this study provide insights into achieving better inclusive

growth and maintaining sustainable and balanced economic development. Based on this, policy recommendations such as expanding the coverage of inclusive finance, optimizing the energy structure, and changing the economic development model are put forward.

Keywords Inclusive growth · Financial inclusion · Renewable energy consumption · Spatial Durbin model (SDM) · Adjustment effect

Introduction

Financial inclusion allows businesses and individuals to access financial products and services at an affordable and sustainable cost. The World Bank identified financial inclusion as a key enabler for 7 of the 17 United Nations Sustainable Development Goals (SDGs). The impact of financial inclusion on the macro economy is multifaceted. Meanwhile, the expansion of the coverage of the financial system is conducive to the optimal allocation of resources (Han & Shen, 2015). The implementation of financial inclusion policies has provided support for low-income people to obtain credit financial services, which is conducive to narrowing the gap between incomes (Ji et al., 2021; Kim, 2016), resulting in a more prosperous economy and higher economic growth (King & Levine, 1993a). On the other hand, financial inclusion plays an important role in

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mitigating the impact of macroeconomic shocks on households and small- and medium-sized enterprises (Corrado & Corrado, 2017). Financial inclusion can boost household savings and encourage entrepreneurs to invest in production, thereby promoting economic growth (Dupas & Robinson, 2013). Moreover, existing research has shown that financial products have a direct role in promoting economic growth (Ayyagari et al., 2011; Levine, 2005), and financial inclusion is of great significance in promoting inclusive economic growth. With the significant impact of the COVID-19 pandemic on the global economy, countries around the world are eager to pursue economic recovery and sustainable development. Re-examining the global financial inclusion strategy is essential to effectively promote inclusive growth.

Green energy, especially renewable energy, plays an important role in achieving sustainable development targets. Maji (2015) showed that every 1% increase in green energy consumption increases economic growth by 1.26%, which can effectively mitigate the negative impact of the COVID-19 pandemic. Furthermore, Wang (2021) also confirmed the promoting effect of green energy utilization on economic growth. However, the current consumption of renewable energy in most countries remains relatively low, while the transition cost of energy to renewable energy is relatively large. When the industrial upgrading and energy structure transformation reach a certain level, the promoting effect of renewable energy on the economy is lacking, which leads to the discussion of the mechanism of industrial structure upgrading in the impact of renewable energy consumption on inclusive growth in this paper.

In the face of the increasingly severe global environmental governance pressure, the internal relationship between the rapidly increasing level of financial inclusion and inclusive growth must be assessed. This paper attempts to study the impact and mechanism of financial inclusion and renewable energy consumption on inclusive growth from an international perspective, and further analyze the impact of industrial structure upgrading, technological progress, government loans, population density, and education levels. Based on the principles of data availability and completeness, we selected relevant data from 40 countries (including 22 developed countries and 18 emerging countries) from 2010 to 2020 (Appendix 1) for

empirical analysis. A significant positive relationship between financial inclusion and renewable energy consumption in these 40 countries was observed (Appendices Figs. 2 and 3).

This paper attempts to extend the existing literature with these contributions: First, to the best of our knowledge, this study is the first to explore the link between financial inclusion, renewable energy, and inclusive growth, bringing financial inclusion and renewable energy consumption together into one system. Secondly, this study is also the first to conduct research from an international perspective, expanding the research perspective. Finally, this study conducts a specific empirical test on the relationship between financial inclusion, renewable energy, and inclusive growth, and the moderating effect of industrial structure based on the fixed-effects spatial Durbin model (SDM), as well as on robustness and endogeneity tests.

The rest of this article is organized as follows. The “[Literature review](#)” section reviews literature on the development of inclusive growth and its relationship to financial inclusion and renewable energy consumption and proposes relevant hypotheses. The “[Empirical research design](#)” section explains our sample selection, data, and methods. The “[Empirical analysis](#)” section presents the empirical results. The “[Robustness and endogeneity tests](#)” section discusses the results of the robustness and endogeneity tests. The “[Results and discussion](#)” section presents relevant conclusions, recommendations, and further considerations.

Literature review

In 2007, the Asian Development Bank first proposed the new concept of “Inclusive Growth,” emphasizing the narrowing of gaps and achieving equal opportunities in the process of economic development (Corak, 2013). The outbreak of the global financial crisis in 2008 aroused the attention of all countries to inclusive economic growth. In 2013, the International Monetary Fund (IMF) made inclusive growth a key element of its 2014 research agenda. The Organization for Economic Co-operation and Development (OECD) and the United Nations Environment Programme (UNEP) were also involved in formulating

policy documents that promote inclusive growth. Since then, academic research on inclusive growth has continued to deepen. The existing literature mainly focuses on inclusive growth from the following three aspects: concept/connotation, measurement, and impact mechanisms. First, we consider the concept and connotation of inclusive growth. Currently, there is no unified definition of inclusive growth. Ali and Zhuang (2007) and Rauniyar and Kanbur (2010) suggested that the inclusive growth is sustainable and considers equal opportunities. The OECD and UNEP defined inclusive growth as growth which reduces poverty and inequality and benefits marginalized populations. In 2018, the UNEP provided a more comprehensive measure of inclusive growth (i.e., the Inclusive Wealth Index). Nonetheless, there is consensus that inclusive growth ensures fairness in the process of economic growth. Second, we consider the measurement of inclusive growth. There are few quantitative studies on inclusive growth in the existing literature. At the same time, different scholars have different measurement methods and indicator system choices for qualifying inclusive growth (Raheem et al., 2018). In the early stages of research, inclusive growth was mainly measured through a single index and focused on the equality of opportunity (Ali & Son, 2007; Silber & Son, 2010). As the research has advanced, the connotation of inclusive growth has been expanded. The construction of the indicator system now mainly involves different dimensions such as the equality of opportunity, income distribution, and economic growth. For example, McKinley (2010) constructed a compound inclusive growth indicator from the four aspects of economy, income, society, and ability, while Berg and Ostry (2017) measured inclusive growth from the two aspects of income growth and distribution. Third, we consider the impact mechanism of inclusive growth. The existing literature mainly focuses on the impact mechanism of inclusive growth from the aspects of international trade, financial development, infrastructure construction, and energy consumption. For example, Farhana et al. (2012) studied the relationship between urbanization and inclusive growth and found that when urbanization develops to a higher level, it may have a negative impact on the inclusive growth of developing countries. In other research, Kapoor (2014)

and Zou and He (2018) examined the mechanism of digital finance and financial development promoting inclusive growth, while Marinas et al. (2018) and Sugiawan and Managi (2019) explored the impact of energy consumption on economic sustainability, proving the two-way causal relationship between renewable energy consumption and economic growth.

Financial development contributes to economic growth (Kapoor, 2014; King & Levine, 1993b), and the development of financial inclusion is an important measure to achieve inclusive growth. Conversely, financial inclusion affects inclusive growth in three ways: First, the development of financial inclusion can increase economic momentum (Dixit & Ghosh, 2013). This is because the development of finance is the driving force of economic development. Through the development of financial inclusion, it is of great significance to reduce costs and promote technological innovation. On the one hand, the “long tail effect” of Internet technology can reduce the marginal cost of financial services (Osmani et al., 2020), while on the other hand, financial development requires the support of digital technology, which can effectively reduce cost. The combination of the two can better boost economic momentum and release economic potential. Second, financial inclusion is conducive to better realization of equal opportunities. According to the theory of financial promotion and Romer’s theory of equal opportunity, important factors hindering equality of opportunity include disadvantages caused by the environment, while financial inclusion can expand the service boundary. This has resulted in important contributions toward promoting the optimal allocation of financial resources in poverty-stricken areas, as well as solving the “financing difficulties” of small, medium, and micro enterprises, and providing special funds for health care, employment, and education. Third, financial inclusion is conducive to sharing results and reducing gaps. Financial inclusion can not only bring capital to rural areas through Internet technology, but also promote cross-space allocation of resources and achieve coordinated economic development among regions. In addition, financial inclusion can reduce the income gap through direct and indirect methods such as income distribution effects, reduction of loan costs, and improvement of human capital (Schmied & Marr, 2016).

The rational use of natural resources, especially energy, is key to green economic growth (Apergis & Danuletiu, 2014; Bildirici, 2014; Chen et al., 2007). Meanwhile, resources, although generally limited, are the material basis of economic growth, and green economic growth depends on the rational use of resources (Zhe et al., 2021). The conversion of resources into capital and labor can create crowding-out effects that limit economic growth. The impact of renewable energy consumption on economic growth also varies from region to region. For example, Maji et al. (2019) studied the relationship between renewable energy consumption and economic growth in West Africa and showed that renewable energy consumption reduced the economic growth rate of these countries. This is consistent with the findings of Ahmed and Shimada (2019) and Sugiawan and Managi (2019). However, Marinaş et al. (2018) and Lee (2019) reached an opposite conclusion. Those authors argued that there is sufficient evidence that renewable energy consumption has a positive relationship with sustainable economic growth, possibly because renewable energy consumption can suppress negative environmental impacts. Research by Fankhauser and Jotzo (2018), Ohene-Asare et al. (2020), and Kouton (2021) also confirmed that energy efficiency improvements can promote sustainable economic growth. In addition, we noticed that with the development of the economy, the industrial structure of each country has also undergone major changes. At a certain level, the industrial structure upgrade can promote economic growth (Chenery, 1975). From the perspective of inclusive growth, when the level of the industrial structure is low, renewable energy and energy transformation are conducive to reducing the investment of enterprises, innovating the concept of enterprise development, and therefore the extra funds of enterprises can be used for technological innovation, thereby promoting the development of the industrial structure to an advanced level and promoting green economic growth (Xie et al., 2020). With the advancement of national-level industrial transformation and upgrading, an increasing number of energy resources will be required in this process, and the use of renewable energy will be subject to certain restrictions, such as higher storage technology requirements and higher development costs. At this point, the positive impact of increased renewable energy consumption on inclusive growth will diminish.

In summary, the current research on inclusive growth is gradually expanding, but data on the relationship between the development of financial inclusion, renewable energy consumption, and inclusive growth remain limited. Existing literature has primarily focused on the relationship between financial inclusion, renewable energy consumption, and economic growth, without considering inclusive growth. In the international context of the pursuit of inclusive growth, it is of great significance to study the relationship between financial inclusion and renewable energy consumption and economic growth. Furthermore, existing research lacks empirical research at the international level. The above research has a certain foreshadowing effect on this paper. This paper focuses on the impact of financial inclusion and renewable energy consumption on inclusive growth and examines the impact of the synergistic mechanism of renewable energy consumption and industrial structure upgrading on inclusive growth. Through the above literature review and analysis, the mechanism underlying financial inclusion, renewable energy development, and inclusive growth is elucidated (Fig. 1), with the following three assumptions put forward:

H1: There is a significant positive correlation between financial inclusion and inclusive growth.

H2: There is a significant positive correlation between renewable energy consumption and inclusive growth.

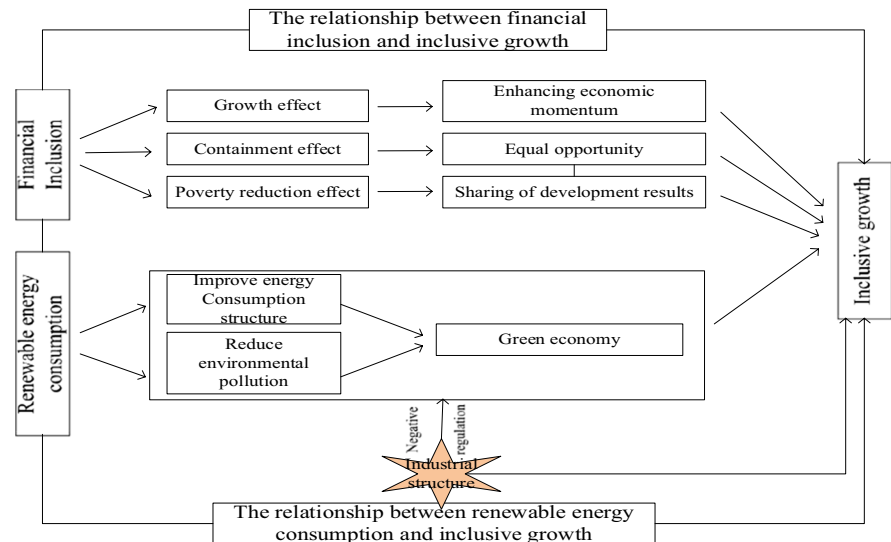
H3: The industrial structure plays a negative role in regulating the relationship between renewable energy consumption and inclusive growth, that is, the higher the industrial structure, the weaker the role of renewable energy consumption in promoting inclusive growth.

Empirical research design

Sample and data selection

In this study, potential survivorship bias and omitted variable bias were avoided using a balanced panel sample. Due to the lack of most of the data, considering the principles of comprehensiveness, rationality, and completeness of the data, we selected 40 countries as research samples. For accuracy, considering

Fig. 1 The mechanism of financial inclusion, renewable energy consumption, and inclusive growth



the impact of the epidemic, the panel length was 2010–2020, and the data were primarily obtained from IMF, the World Bank (WB), and BP Energy Statistics Yearbook.

Variable design

The variables in this paper are mainly divided into explained, explanatory, and control variables. The explained variables are inclusive growth (*IG*); the explanatory variables are financial inclusion (*IFI*) and renewable energy consumption (*REC*); and the control variables are industrial structure upgrade (*IS*), technological progress (*TC*), government loans (*GL*), population density (*PD*), and education level (*EL*).

The interpretation and calculation methods of each variable are as follows:

1. **Inclusive growth (*IG*):** The explained variable here is inclusive growth, denoted by *IG*. The definition of inclusive growth revolves mainly around the equality of growth. The Asian Development Bank believes that inclusive growth is related to economic, social, and institutional opportunities equally available to everyone. The UNDP considers inclusive growth to be economic growth that enables more individuals, regions, or countries to gain wider access to sustainable socio-economic opportunities. Meanwhile, the United Nations uses GDP per capita as an important proxy for achieving the SDGs; Tella and Alimi

(2016), Oluseye and Gabriel (2017), and Raheem et al. (2018) also used the same proxy variable to measure inclusive growth. Notably, there may be some limitations in using the logarithm of GDP per capita as a proxy for inclusive growth. However, this variable allows us to study the impact of financial inclusion and renewable energy consumption on inclusive growth (equality of the economy), which has important implications for achieving better economic equality and sustainability goals.

2. **Financial inclusion (*IFI*):** We used the financial development index in the IMF and the measured financial inclusion index to measure the level of financial inclusion (the financial inclusion index is mainly used for robustness testing). The calculated financial inclusion index draws on the studies of Sarma (2015), Mushtaq and Bruneau (2019), Dabla-Norris et al. (2021), and Nizam et al. (2020). Herein, we measured financial inclusion from four dimensions: bank penetration, bank service availability, financial service use effectiveness, and financial service use sustainability. Bank penetration rate is measured by the number of bank deposit accounts per thousand people; banking service availability is measured from two dimensions: geographic dimension (number of ATMs per 1,000 km², number of commercial bank branches per 1,000 km²) and demographic dimension (number of ATMs per 100,000 adults, number of commercial bank

branches per 100,000 adults); the use effectiveness of financial services is measured by the ratio of the balance of deposits and loans to GDP, and the use of financial services is measured by the ratio of non-performing loans to sustainability.

In order to reflect the difference in the contribution rate of various indicators to the development of financial inclusion, we adopted the entropy method to determine the index weight. After determining the weight of each indicator, the level of financial inclusion development index was measured using the method of the UMDP to compile the Human Development Index. The measurement formula is as follows:

$$IFI_i = 1 - \frac{\sqrt{(w'_1 - Z'_1)^2 + (w'_2 - Z'_2)^2 + \dots + (w'_v - Z'_v)^2}}{\sqrt{w_1'^2 + w_2'^2 + \dots + w_v'^2}} \quad (1)$$

where IFI_i represents the financial inclusion index of the i th country, Z'_v represents the evaluation value of the v th index that measures the inclusive financial development index, w'_v represents the weight of the v th index determined by the entropy weight method, and $Z'_v = w'_v \times X_{iv}$. X_{iv} is the standardized value of the v th index that measures the inclusive financial development index.

3. Renewable energy consumption (*REC*): We used the ratio of renewable energy consumption to primary energy consumption in the BP Energy Statistical Yearbook to measure renewable energy consumption. Renewable energy utilization is the key to energy transformation. Increasing renewable energy consumption to reduce the proportion of fossil energy consumption is an important measure to protect the environment and actively respond to climate change, which is of great significance for economic growth.

The increased consumption of renewable energy indicates that environmental problems have been improved to a certain extent, and resources play a positive role in the economy.

4. Industrial structure upgrading (*IS*): According to Petty-Clark's law on the evolution of industrial structure, we measured the upgrading of industrial structure using the methods of Song et al. (2021) as follows:

$$IS = \sum_{i=1}^3 y_i \times i = y_1 \times 1 + y_2 \times 2 + y_3 \times 3 \quad (2)$$

where y_i represents the proportion of the output value of the i th industry, and *IS* is the level of industrial structure upgrading, which reflects the sequential evolution of the industrial structure from the primary industry to the secondary industry and the tertiary industry. The larger the value of *IS*, the higher the level of the industrial structure.

5. Interaction term (*REC* × *IS*): The product of interaction terms is mainly used to illustrate the moderating effect of industrial structure upgrading between renewable energy consumption and inclusive growth.
6. Technological progress (*TC*): We selected the number of patent applications to represent technological progress, which reflects the country's technological innovation capability.
7. Government loans (*GL*): We used the ratio of total government loans to GDP to measure government loans.
8. Population density (*PD*): The larger the population density of a country, the more difficult it is to achieve equality in economic growth, and the population density is not conducive to the realization of inclusive growth.
9. Educational level (*EL*): We used the years of primary education to measure the educational level. Education is an important source of economic growth and providing more of it is an important way to achieve equality in economic growth. Oyinlola and Adedeji (2019) and van Kreveld (2021) have shown that human capital and education are important influencing factors of both economic and sustainable growth.

Descriptive statistics

Table 1 provides the descriptive statistics for each variable. The variance inflation factor (VIF) is less than 10, indicating no multicollinearity problem.

Table 1 Data descriptive statistics

Variable	Meaning	Mean	Standard deviation	Minimum	Maximum	VIF
<i>IG</i>	Inclusive growth	9.5180	1.0180	7.1220	11.3898	—
<i>IFI</i>	Financial inclusion	0.5084	0.2027	0.1247	0.9826	3.30
<i>REC</i>	Renewable energy consumption	0.7104	1.8109	-7.7307	2.9571	1.53
<i>IS</i>	Industrial structure upgrading	0.8509	0.0526	0.6976	0.9768	2.58
<i>TC</i>	Technological progress	6.5404	2.2645	0.6931	14.1476	1.66
<i>GL</i>	Government loans	3.8125	0.7132	0.4459	5.3529	1.72
<i>PD</i>	Population density	4.3693	0.9735	2.5460	6.2747	1.58
<i>EL</i>	Educational level	1.7104	0.1656	1.3863	2.0794	1.38

All variables except financial inclusion are natural logarithms

Model settings

Spatial autocorrelation analysis

Spatial autocorrelation indicates that regions with similar locations have similar variable values. In spatial econometrics, the Moran index (*I*) is used to measure the spatial autocorrelation. At $I > 0$, the variable value shows a positive spatial autocorrelation, otherwise it is a negative spatial correlation. The calculation formula is as follows:

$$I = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (y_i - \bar{y})(y_j - \bar{y})}{s^2 \sum_{i=1}^n \sum_{j=1}^n (y_i - \bar{y})^2} \tag{3}$$

where y_i and y_j are the variable values of the i th and j th countries, $s^2 = \frac{1}{n} \sum_{i=1}^n (y_i - \bar{y})^2$, $\bar{y} = \frac{1}{n} \sum_{i=1}^n y_i$, n is the number of countries, and w_{ij} is the element in the spatial weight matrix. The spatial weight matrix

mainly used in this paper is mainly the geospatial weight matrix (w_d), which is obtained according to the reciprocal of the absolute value of the latitude and longitude distance between the two regions.

Spatial econometric model

To study the driving effects of factors such as financial inclusion and renewable energy consumption on inclusive growth, this paper constructs SDM for analysis. The SDM includes both the lag term of the spatial dependent variable and the lag term of the spatial independent variable, and can reflect the spillover effects produced by different influencing factors, specifically:

$$IG_{it} = \alpha + \rho WIG_{it} + \beta_1 IFI_{it} + \beta_2 REC_{it} + \beta_3 IS_{it} + \beta_4 TC_{it} + \beta_5 GL_{it} + \beta_6 PD_{it} + \beta_7 EL_{it} + \delta_1 WIFI_{it} + \delta_2 WREC_{it} + \delta_3 WIS_{it} + \delta_4 WTC_{it} + \delta_5 WGL_{it} + \delta_6 WPD_{it} + \delta_7 WEL_{it} + \mu_i + \epsilon_{it} \tag{4}$$

where i and t represent country and year, respectively. *IG* represents inclusive growth, *IFI* and *REC* represent financial inclusion and renewable energy consumption, respectively. *IS*, *TC*, *GL*, *PD*, and *EL* represent industrial structure upgrading, technological progress, government loans, population density, and education level, respectively. ρ is the spatial correlation coefficient, W is the spatial weight matrix, μ_i is the individual effect, and ϵ_{it} is the random disturbance term.

To further explore the impact of renewable energy consumption and industrial structure upgrading on inclusive growth, this paper introduces the interaction term of renewable energy consumption and industrial

Table 2 Results of the unit root test

Variable	LLC test	IPS test	Fisher-PP test
<i>IG</i>	-2.2273**	-3.4521***	140.2855***
<i>IFI</i>	-9.1989***	-5.3964***	192.4749***
<i>REC</i>	-8.9896***	-2.6443***	179.6214***
<i>IS</i>	-5.3561***	-2.0098**	163.5019***
<i>TC</i>	-8.2473***	-2.0284**	141.1993**
<i>GL</i>	-4.1411***	-2.0638**	161.4792**
<i>PD</i>	-8.9420***	-3.4742***	210.5041***
<i>EL</i>	-2.1430**	-3.5515***	218.9880***

***, **, and * indicate that the variable is significant at the significance level of 1%, 5%, and 10%, respectively, and the following table is the same

structure upgrading into the model. The model is set as follows:

$$\begin{aligned}
 IG_{it} = & \alpha + \rho WIG_{it} + \beta_1 IFI_{it} + \beta_2 REC_{it} \\
 & + \beta_3 IS_{it} + \beta_4 TC_{it} + \beta_5 GL_{it} + \beta_6 PD_{it} \\
 & + \beta_7 EL_{it} + \delta_1 WFI_{it} + \delta_2 WREC_{it} \\
 & + \delta_{23} WREC_{it} \times IS_{it} + \delta_3 WIS_{it} \\
 & + \delta_4 WTC_{it} + \delta_5 WGL_{it} + \delta_6 WPD_{it} \\
 & + \delta_7 WEL_{it} + \mu_i + \epsilon_{it}
 \end{aligned}
 \tag{5}$$

where $REC \times IS$ represents the interaction term between renewable energy consumption and industrial structure upgrading, which reflects the adjustment effect of industrial structure upgrading on the impact of renewable energy consumption on inclusive growth. The other variables are the same as those of Eq. (4).

Empirical analysis

Unit root test

In this study, homogeneous Levin-Lin-Chu (LLC) panel unit root test, heterogeneous IPS test, and Fisher-PP panel unit root test were used to determine whether each variable is stable. The three test results show that these seven variables are all stable. The test results are listed in Table 2.

Spatial autocorrelation test

Based on the inclusive growth index of 40 countries from 2010 to 2020, we used a geospatial weight matrix combined with the global Moran index to

conduct a spatial autocorrelation test. The test results are shown in Table 3.

Table 3 shows that under the geospatial weight matrix, the global Moran index values of the inclusive growth index in all years are significantly positive. Therefore, the global inclusive growth index has a significant positive spatial correlation, with a significantly convergence and aggregation phenomenon in the spatial distribution. That is, a country with a higher level of inclusive growth has a higher level of inclusive growth in its neighboring countries, while the one with a lower level of inclusive growth has a lower level of inclusive growth. Therefore, the research analysis can be carried out using the spatial econometric model.

Model screening

The results of the spatial autocorrelation test show that the inclusive growth has a significant positive spatial correlation, indicating that a spatial panel model can be established. Before performing spatial panel regression, a series of spatial correlation tests are required to finalize the spatial model that best interprets the data. Ordinary least squares estimation is first needed to obtain the estimated residuals of the model, where the spatial autocorrelation test is performed. At the same time, the Lagrange multiplier (LM) test and robust LM test proposed by Anselin (1988) are used to determine whether there is a spatial error model and a spatial lag model. Therefore, this paper first performed ordinary least squares estimation and LM and robust LM tests based on the geospatial weight matrix. The results are shown in Table 4. The spatial autocorrelation, the LM, and the robust LM tests pass in the models without

Table 3 Results of the global Moran index test

Year	<i>I</i>	Z-value	P-value	Year	<i>I</i>	Z-value	P-value
2010	0.117***	3.763	0.000	2016	0.119***	3.811	0.000
2011	0.118***	3.786	0.000	2017	0.122***	3.864	0.000
2012	0.117***	3.763	0.000	2018	0.123***	3.893	0.000
2013	0.115***	3.727	0.000	2019	0.124***	3.938	0.000
2014	0.116***	3.750	0.000	2020	0.122***	3.888	0.000
2015	0.118***	3.785	0.000				

Table 4 Results of the LM and robust LM tests

Testing method	Without interaction		With interaction	
	Statistics	P-value	Statistics	P-value
Moran's I	432.529	0.000	432.273	0.000
LM-Error	50.156	0.000	50.254	0.000
Robust LM-Error	40.679	0.000	40.539	0.000
LM-Lag	160.900	0.000	165.079	0.000
Robust LM-Lag	151.423	0.000	155.365	0.000

interaction terms and with interaction terms, indicating that both the spatial lag model (SAR) and the spatial error model (SEM) can be used, and SDM must be considered.

After that, the log-likelihood ratio test (LR) and Wald test were used to determine whether the SDM is degraded to the SAR or the SEM, to select the best model. According to the principles of the Wald and LR tests, two null hypotheses $H_0 : \theta = 0$ and $H_0 : \theta + \rho\beta = 0$ are given, and two hypothesis tests are carried out in turn. The two hypothesis tests are used to judge whether the SDM can be reduced to SAR or SEM, respectively. If both the Wald and LR tests reject both null hypotheses, the SDM is selected. The results of the Wald and LR tests for this study are shown in Table 5. Under the geospatial weight matrix, regardless of whether the interaction terms of renewable energy consumption and industrial structure upgrading are added, the results of the Wald_spatial_lag and LR_spatial_lag tests strongly reject the null hypothesis of $\theta = 0$ at the 1% significance level, that is, the SDM does not degenerate into the

Table 5 Results of the Wald, LR, and Hausman tests

Testing method	Without interaction		With interaction	
	Statistics	P-value	Statistics	P-value
Wald_spatial_lag	104.88	0.000	112.12	0.000
LR_spatial_lag	103.46	0.000	109.92	0.000
Wald_spatial_error	112.20	0.000	119.12	0.000
LR_spatial_error	118.21	0.000	124.68	0.000
Hausman test	47.80	0.000	72.84	0.000

SAR. According to the results of the Wald_spatial_error and LR_spatial_error tests, they also passed the significance test; hence, the SDM should be selected. In addition, the statistics of the Hausman test of the SDM without interaction terms and with interaction terms under the geospatial weight matrix were 47.8 and 72.84, respectively, and both passed the 1% significance level test. Therefore, this study selected the SDM under the fixed effect model for analysis.

Results and analysis

Financial inclusion, renewable energy consumption, and inclusive growth

This study first explored the relationship between financial inclusion, renewable energy consumption, and inclusive growth when there is no interaction term based on the geospatial weight matrix and using the SDM. At the same time, to highlight the influence of control variables, we listed the estimation results of the SDM without the control variable space and the SDM with the control variable space. The relevant results are shown in columns (1) and (2) of Table 6. The spatial autocorrelation coefficients all passed the significance level test, which further confirms the spatial autocorrelation coefficients. This shows that inclusive growth has a spatial spillover effect. The inclusive economic development of a country may quickly spread to surrounding areas, which not only promotes the inclusive growth of its own country, but also improves the level of inclusive growth of surrounding countries. After adding relevant control variables, the impact of renewable energy consumption on inclusive growth changed from insignificant to significant, while the model's goodness of fit (R^2) and log-likelihood (Log-Likelihood) increased significantly. Therefore, the following analysis will focus on the estimation results of fitting the SDM after adding control variables.

Financial inclusion has a significant positive impact on the inclusive growth. In the SDM, the coefficient of financial inclusion passed the 1% significance test, while a significant positive correlation was observed between financial inclusion and inclusive growth. The development of financial inclusion will improve the level of inclusive growth. In this study, H1 was

Table 6 Regression results of the SDM

Variable	(1)	(2)	(3)	Variable	(1)	(2)	(3)
<i>IFI</i>	0.7750*** (5.91)	0.4138*** (3.44)	0.3958*** (3.29)	<i>W * IFI</i>	92.0389*** (3.37)	94.8617*** (3.35)	73.6388** (2.31)
<i>REC</i>	0.0042 (0.81)	0.0127** (2.22)	0.1263** (2.61)	<i>W * REC</i>	3.8908*** (5.78)	4.3232*** (2.94)	26.2143 (1.23)
<i>REC × IS</i>	—	—	-0.1393** (-2.37)	<i>W * REC × IS</i>	—	—	-27.3581 (-1.05)
<i>IS</i>	—	0.7560*** (2.95)	0.8288*** (3.24)	<i>W * IS</i>	—	-0.3421 (-0.01)	51.9379 (0.68)
<i>TC</i>	—	0.0554*** (4.89)	0.0529*** (4.69)	<i>W * TC</i>	—	4.2395 (1.55)	3.7204 (1.31)
<i>GL</i>	—	-0.0931*** (-7.40)	-0.0994*** (-7.80)	<i>W * GL</i>	—	-1.1515 (-0.37)	-0.5192 (-0.17)
<i>PD</i>	—	-0.1674 (-1.32)	-0.1223 (-0.95)	<i>W * PD</i>	—	150.7010*** (4.02)	180.6642*** (4.57)
<i>EL</i>	—	0.0588 (0.37)	0.0254 (0.16)	<i>W * EL</i>	—	341.4476*** (4.29)	335.9776*** (4.24)
ρ	18.9347*** (4.42)	10.6439* (1.92)	9.7016* (1.72)				
<i>sigma2_e</i>	0.0041*** (14.77)	0.0030*** (14.81)	0.0030*** (14.81)				
R^2	0.3446	0.5471	0.5549				
Log-Likelihood	581.8772	652.8686	656.1177				

The values in parentheses represent Z statistics

verified. This has also been confirmed in the studies of Kapoor (2014) and Zou and He (2018). The vigorous development of financial inclusion helps to expand the breadth and depth of financial services, making the coverage of the financial system wider; it also reduces people’s economic risks, which helps to reduce residents’ constraints and facilitates transactions, and promotes human capital and material rational allocation of capital. These factors ultimately contribute to the development of an inclusive economy.

Renewable energy consumption significantly contributes to inclusive growth. The coefficient of renewable energy consumption was 0.0127, significant at the 5% significance level, indicating that increasing renewable energy consumption helps to promote inclusive growth, thereby confirming H2. Renewable energy, as a green and low-carbon energy source, is a powerful driving force for economic growth and plays an irreplaceable role in social production. Increasing the consumption of renewable energy indicates that the proportion of fossil energy consumption

will decrease, which will help to improve the energy structure, ensure energy security, and achieve sustainable economic and social development. In addition, the increase in renewable energy consumption can also reduce environmental pollution, reduce environmental governance costs, and actively respond to climate change, thereby ensuring long-term and stable growth of the country’s inclusive economy.

Industrial structure upgrading has a significant positive impact on inclusive growth. This shows that improving the level of industrial structure, optimizing the industrial structure of traditional industries, accelerating the integration of industry and service industries, and promoting the flow of factors and the optimal allocation of resources are conducive to improving the level of inclusive economic growth in the country. The influence coefficient of technological progress was 0.0554, indicating that technological progress has a positive impact on inclusive growth, and this effect passed the 1% significance level test.

These findings indicate that technological progress itself will improve the production efficiency of various factors in the sector and thus promote the growth of an inclusive economy. Government loans have a significant negative impact on inclusive growth, which means that countries with higher government loans have relatively low levels of inclusive economic growth. Government loans often reflect the comprehensive strength of a country. Usually, countries with higher loans are less capable of inclusive development.

Based on the estimation results of the SDM, this study used the decomposition method of partial differential equations (Lesage & Pace, 2009) to decompose the effects of changes in the explanatory variables in the model into direct effects and indirect effects. The direct effect represents the influence of a country's explanatory variable on the explained variable and includes the impact on neighboring countries and the impact on the country in turn. The indirect effect represents the spatial spillover effect, which reflects the influence of the domestic explanatory variables on the explained variables of neighboring countries. The total effect is the sum of the two, specifically explained as the average effect of the change in the explanatory variable of a country on

the explained variable of all countries. According to the above decomposition method, we further explored the direct and indirect effects of a country's inclusive growth by factors such as financial inclusion and renewable energy consumption in its own country and neighboring countries. The results are shown in column (1) of Table 7.

Most of the influencing factors have a certain spatial spillover effect on global inclusive growth. Specifically, under the geospatial weight matrix, both the direct and indirect effects of financial inclusion are significantly positive at the 1% significance level. This shows that the improvement of the level of financial inclusion in the country will have a positive impact on the inclusive growth of the country on the one hand, while also promoting the development of the inclusive economy of neighboring countries on the other hand. Both direct and indirect effects of renewable energy consumption are also significant, suggesting that increased renewable energy consumption in home and neighboring countries will promote inclusive economic growth. The direct effect of industrial structure upgrading is significantly positive, indicating that the continuous improvement of the industrial structure level is conducive to the inclusive growth of the country, but has no significant impact

Table 7 Decomposition of spatial spillover effects

Variable	(1)			(2)		
	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect
<i>IFI</i>	0.4528*** (3.65)	2.1669*** (3.15)	2.6197*** (3.70)	0.4277*** (3.36)	1.7756** (2.31)	2.2033*** (2.73)
<i>REC</i>	0.0139** (2.47)	0.0978*** (3.60)	0.1117*** (3.88)	0.1328*** (2.75)	0.5818 (1.23)	0.7146 (1.46)
<i>REC × IS</i>	—	—	—	−0.1450** (−2.46)	−0.6062 (−1.04)	−0.7512 (−1.25)
<i>IS</i>	0.7850*** (3.17)	0.2592 (0.18)	1.0442 (0.72)	0.8461*** (3.32)	1.3933 (0.78)	2.2394 (1.23)
<i>TC</i>	0.0572*** (5.09)	0.1116 (1.51)	0.1688** (2.22)	0.0546*** (4.99)	0.0939 (1.22)	0.1485* (1.86)
<i>GL</i>	−0.0935*** (−7.67)	−0.0451 (−0.70)	−0.1386** (−2.10)	−0.0991*** (−7.86)	−0.0312 (−0.50)	−0.1304** (−2.06)
<i>PD</i>	−0.1104 (−0.86)	3.2208*** (3.52)	3.1104*** (3.32)	−0.071 (−0.53)	3.8407*** (3.67)	3.7697*** (3.49)
<i>EL</i>	0.1792 (0.99)	7.5820*** (3.83)	7.7612*** (3.71)	0.1354 (0.80)	7.3768*** (3.89)	7.5123*** (3.78)

The values in parentheses represent Z statistics

on neighboring countries. The direct effect of technological progress has passed the 1% significance level test, which shows that for every 1 unit increase in technological progress, the country's inclusive growth level will increase by 0.0572, with no significant spillover effect. The direct effect of government loans is significant, but the indirect effect is not significant, indicating that when domestic government loans increase by 1 unit, the level of inclusive growth in the country will decrease by 0.0935.

The relationship between financial inclusion, renewable energy consumption, and inclusive growth under the upgrading of industrial structure

This study explored the impact of renewable energy consumption on inclusive growth in the context of industrial structure upgrading by introducing the interaction term between industrial structure upgrading and renewable energy consumption. The results of fitting SDM under the geospatial weight matrix and the estimation results are shown in column (3) of Table 6. The goodness of fit (R^2) of the model was 0.5549, and the log-likelihood value (Log-Likelihood) was 656.1177, which is higher than the results in column (2), indicating that the model fits very well. At the same time, the spatial autocorrelation coefficient ρ remained significantly positive, indicating that inclusive growth has a spatial spillover effect.

The coefficient of financial inclusion is significantly positive, indicating that the role of financial inclusion in promoting inclusive growth is still stable. Meanwhile, the interaction term between renewable energy consumption and industrial structure upgrading is significantly negative in the model, which indicates that industrial structure upgrading plays a significant negative regulating role between renewable energy consumption and inclusive growth; therefore, H3 is confirmed. With the continuous upgrading of the national industrial structure, the demand for energy in the process will increase. However, due to the shortcomings of instability, low efficiency, and high cost of renewable energy, continuing to increase the use of renewable energy at this time will only lead to a more significant cost effect, which will have a certain impact on inclusive economic growth. Therefore, with the evolution of the advanced industrial structure, the role of renewable energy consumption in promoting inclusive growth will be reduced. In

addition, the influence direction and significance of other control variables on inclusive growth are consistent with the estimation results of the SDM without introducing interaction terms (column (2) in Table 6).

To further explore the spatial spillover effect of the impact of financial inclusion and renewable energy on inclusive growth under the upgrading of industrial structure, this study further decomposed the spatial effect of the main body, and analyzed its direct and indirect effect, as shown in column (2) of Table 7. The direct and indirect effects of financial inclusion on inclusive growth remain significantly positive, indicating that the improvement of a country's financial inclusion level can indeed drive inclusive economic growth in the country and neighboring countries. The direct effect of the interaction term between renewable energy consumption and industrial structure upgrading is significant, while the indirect effect is not, indicating that the upgrading of industrial structure will weaken the positive promotion effect of renewable energy consumption on the inclusive growth, but will not have an impact on neighboring countries. Notably, the direct and indirect effects of the remaining control variables on inclusive growth are also completely consistent with the decomposition results of the SDM without introducing interaction terms (column (1) in Table 7), and the estimated results are relatively robust.

Robustness and endogeneity tests

Robustness test

To improve the reliability of the research results, we analyzed the robustness of the econometric model. First, the robustness test is carried out by changing the length of the sample period. After excluding the samples of the first year (2010), we estimated based on the SDM under fixed effects, and the results are shown in columns (1) and (2) of Table 8. Comparing the final results with the estimated results in columns (2) and (3) of Table 6 and after changing the length of the sample period, the significance and direction of the coefficients of all core explanatory variables and control variables did not change, while the magnitude and significance level of the coefficients were different. Secondly, we used the method of replacing the core explanatory variables to further assess

Table 8 Results of the robustness test

Variable	Change in the length of the sample period (excluding 2010 data)		Replacing core explanatory variables (finance inclusion)	
	(1)	(2)	(3)	(4)
<i>IFI</i>	0.3252*** (2.58)	0.2981** (2.39)	1.3650*** (9.09)	1.3628*** (9.22)
<i>REC</i>	0.0120** (2.01)	0.1402*** (2.81)	0.0086* (1.65)	0.1371*** (3.05)
<i>REC</i> × <i>IS</i>	—	-0.1574*** (-2.61)	—	-0.1563*** (-2.86)
<i>IS</i>	0.7779*** (3.09)	0.8363*** (3.35)	0.5579** (2.33)	0.6320*** (2.66)
<i>TC</i>	0.0487*** (4.18)	0.0452*** (3.91)	0.0440*** (4.14)	0.0398*** (3.78)
<i>GL</i>	-0.1018*** (-8.11)	-0.1096*** (-8.63)	-0.0985*** (-8.38)	-0.1051*** (-8.93)
<i>PD</i>	-0.0859 (-0.64)	-0.0065 (-0.05)	-0.2602** (-2.18)	-0.1989* (-1.67)
<i>EL</i>	0.0808 (0.51)	0.0403 (0.25)	-0.1080 (-0.73)	-0.1014 (-0.69)
<i>W</i> * <i>IFI</i>	64.5021* (1.95)	37.1608 (1.09)	-58.8493*** (-4.16)	-71.6921*** (-4.95)
<i>W</i> * <i>REC</i>	3.1048** (2.10)	51.4137** (2.29)	-0.3148 (-0.27)	51.1480*** (2.76)
<i>W</i> * <i>REC</i> × <i>IS</i>	—	-59.9818** (-2.17)	—	-62.6246*** (-2.80)
<i>W</i> * <i>IS</i>	18.7236 (0.28)	156.4535* (1.73)	4.9982 (0.08)	144.3600* (1.85)
<i>W</i> * <i>TC</i>	7.0218** (2.40)	5.2289* (1.71)	6.7946*** (2.73)	4.0461 (1.51)
<i>W</i> * <i>GL</i>	-1.5745 (-0.53)	-0.8873 (-0.30)	0.8594 (0.30)	0.2723 (0.09)
<i>W</i> * <i>PD</i>	158.4121*** (4.15)	202.2496*** (5.07)	238.3158*** (6.56)	280.7765*** (7.53)
<i>W</i> * <i>EL</i>	246.4542*** (3.19)	238.8226*** (3.13)	152.0263** (2.17)	202.0217*** (2.82)
ρ	13.0580** (2.35)	11.6770** (2.08)	16.6276*** (3.25)	14.9047*** (2.83)
σ^2_e	0.0025*** (14.11)	0.0025*** (14.12)	0.0026*** (14.77)	0.0026*** (14.78)
R^2	0.5395	0.5564	0.5892	0.6077
Log-Likelihood	626.9287	632.7580	679.2581	687.0804

The values in parentheses represent *Z* statistics

the robustness. After comprehensive calculation, 7 indicators are selected from 4 dimensions of national bank penetration rate, bank service availability, financial service use effectiveness, and financial service

use sustainability. This can be used as a new financial inclusion variable re-incorporated into the SDM for estimation; the results are shown in columns (3) and (4) of Table 8. Comparing with the results in columns

(2) and (3) of Table 6, the core explanatory variables' financial inclusion and renewable energy consumption coefficients have the same significance while the direction remains the same. Except for the negative effect of population density on inclusive growth being significant, the coefficients of other control variables have the same significance and direction. The spatial autocorrelation coefficient ρ is significantly positive, while the goodness of fit (R^2) and log-likelihood (Log-Likelihood) become larger.

Endogenous test

To overcome the endogeneity limitations caused by missing variables in the model, this paper used the system generalized method of moments (GMM) model to solve the endogeneity problem of explained variables and the characteristics of weak instrumental variables; hence, the model is used to address these limitations. By introducing the first-order lag terms of the explained variables to represent other factors not considered in the model (Zhou and Xu, 2022), using the lagged terms of inclusive growth of the explained variable and renewable energy consumption of the core explanatory variable as instrumental variables to eliminate endogeneity, the estimation knot is more efficient.

The results obtained using the system GMM model in this study are shown in Table 9. Columns (1) and (2) represent the results without interaction and with interaction, respectively. Judging from the estimators of the Arellano-Bond test, the P -values of AR(1) all reject the null hypothesis. None of the p -values of AR(2) rejected the null hypothesis of no autocorrelation. This shows that the error sequences have first-order autocorrelation but not second-order autocorrelation, indicating the model has passed the autocorrelation test. The statistic corresponding to the Sargan test cannot reject the null hypothesis of "all instrumental variables are valid," which ensures the validity of the instrumental variables and overcomes the endogeneity problem of the model. The inclusive growth that lags one period has a positive effect on the inclusive growth of 40 countries around the world, indicating that the results of inclusive growth in the early stage can provide basic support for the current inclusive economic development. In addition, the coefficients of financial inclusion and renewable energy consumption are also significantly positive, while the interaction term of renewable energy consumption and industrial structure upgrading is significantly negative. This suggests that the judgment regarding the industrial structure upgrading playing a negative moderating role between renewable energy consumption and inclusive growth is valid under the condition of considering endogeneity, which verifies the validity of the regression results.

Table 9 Results of the endogenous test

Variable	(1)	(2)
<i>LIG</i>	0.9456*** (157.61)	0.9591*** (137.89)
<i>IFI</i>	0.3465*** (12.01)	0.3544*** (12.14)
<i>REC</i>	0.0016** (2.06)	0.1534*** (17.73)
<i>REC</i> × <i>IS</i>	—	−0.1845*** (−17.97)
<i>Control</i>	YES	YES
<i>_cons</i>	0.3197*** (2.88)	0.4093*** (3.91)
<i>AR</i> (1)	−1.6637*	−1.7415*
<i>AR</i> (2)	−0.6986	−0.6631
<i>Sargan</i>	38.8817	38.4070

Results and discussion

Using the panel data from 2010 to 2020 in 40 countries, this study examined the impact of factors such as financial inclusion and renewable energy consumption on global inclusive economic growth based on the SDM, and concludes the following. (1) The inclusive economic growth of 40 countries has a spatial spillover effect, and financial inclusion and renewable energy consumption can promote the inclusive economic growth in the country and neighboring countries. (2) Industrial structural upgrading only plays a negative moderating role between domestic renewable energy consumption and inclusive growth. That is, the upgrading of industrial structure will weaken

the positive role of renewable energy consumption in promoting inclusive growth of the country, yet will not affect neighboring countries. (3) The upgrading of industrial structure and technological progress helps to promote the country's inclusive economic growth, while government loans have a negative impact on the country's inclusive growth.

The conclusions of this study inspire the following approaches for further promoting the growth of inclusive economies in various countries:

- (1) Since financial inclusion can effectively promote the inclusive economic growth of the country and neighboring countries, countries should further expand their coverage of financial inclusion, strengthen the construction of financial infrastructure, increase the number of customers of financial institutions, and improve actual utilization of financial products and services; furthermore, countries should improve the inclusive financial service system, strengthen overall planning, promote the rational allocation of financial resources, allow financial institutions to play a role, and effectively guarantee the economic development. At the same time, national government departments must strengthen the supervision of the market environment for the development of financial inclusion, as well as establish and improve relevant legal systems and promote the sustained and rapid development of financial inclusion.
- (2) The optimization of the energy structure and vigorous development of renewable energy are essential, such as strengthening the reform of energy supply side, actively guiding the transformation of energy consumption structure from fossil to renewable energies, and realizing sustainable energy structure transformation. Countries should formulate active renewable energy policies so as to be able to provide subsidies for renewable energy development; furthermore, countries should combine the resource endowment and technological endowment, as well as promote the development of renewable energy with comparative advantages, expand the potential reserves of energy, and ease the pressure

of energy demand in the process of economic development. Countries should also advocate for energy conservation and emission reduction policies, establish environmental awareness, build a social development model that combines conservation and ecology, and ensure the steady growth of the national economy.

- (3) Countries must actively exert the influence of other factors on inclusive growth, for example, by changing the economic development model, optimizing the industrial structure, expanding employment and domestic demand, and promoting inclusive growth; furthermore, countries should comprehensively improve the overall human capital quality of the country, create a level playing field, improve citizens' quality of life, and promote technological innovation, thereby increasing the contribution of other factors while promoting sustainable and effective economic growth. When raising foreign government loans, attention should be paid to appropriate scale and structure optimization, as well as to deepening economic market reform, reasonably introducing foreign resources and technologies, and enhancing the country's own comprehensive strength in all aspects, to actively lead economic globalization into cooperation, ensuring a new phase of inclusion.

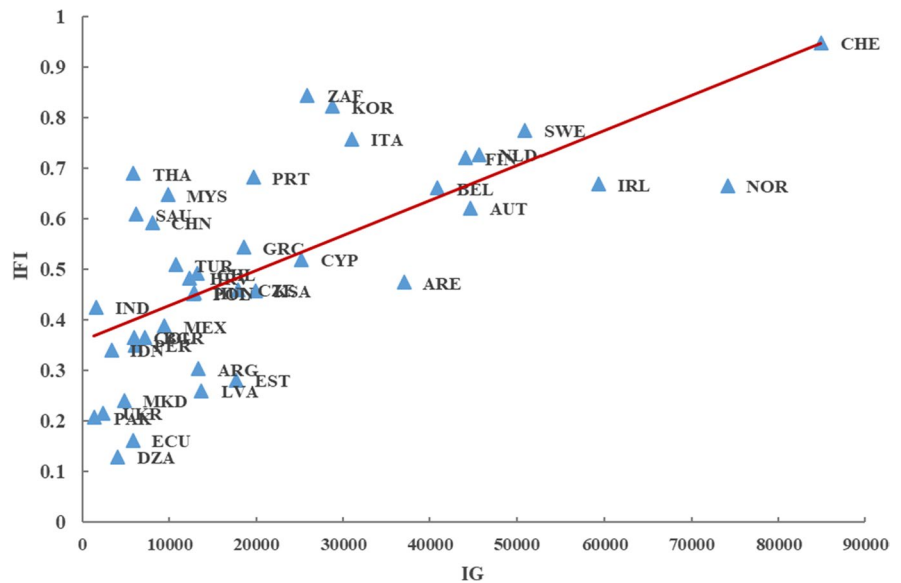
Since the basic connotation of inclusive growth is equitable growth, when selecting indicators to measure it, we only considered the country's per capita GDP, and not the inclusive growth from various perspectives. At the same time, when considering the missing data of some indicators, the method adopted in this study was aimed to fill in the moving binomial average method, which may cause some deviations in the results, without changing the general direction. In addition, due to data limitation, we only considered the impacts of financial inclusion, renewable energy consumption, and advanced industrial structure on inclusive growth, but not other factors; for example, inclusive growth may also be affected by environmental regulations, urbanization, and urban infrastructure construction. These deficiencies are the subjects of future studies.

Appendix 1. List of countries used in the study:

Algeria (DZA), Argentina (ARG), Austria (AUT), Belgium (BEL), Bulgaria (BGR), Chile (CHL), China (CHN), Colombia (COL), Croatia (HRV), Cyprus (CYP), Czech Republic (CZE), Ecuador (ECU), Estonia (EST), Finland (FIN), Greece (GRC), Hungary (HUN), India (IND), Indonesia (IDN), Ireland (IRL), Italy (ITA), South Korea (KOR), Latvia (LVA), Malaysia (MYS), Mexico (MEX), Netherlands (NLD), North Macedonia (MKD), Norway (NOR), Pakistan (PAK), Peru (PER), Poland (POL), Portugal (PRT), Saudi Arabia (SAU), South Africa (ZAF), Spain (ESP), Sweden (SWE), Switzerland (CHE), Thailand (THA), Turkey (TUR), Ukraine (UKR), United Arab Emirates (ARE).

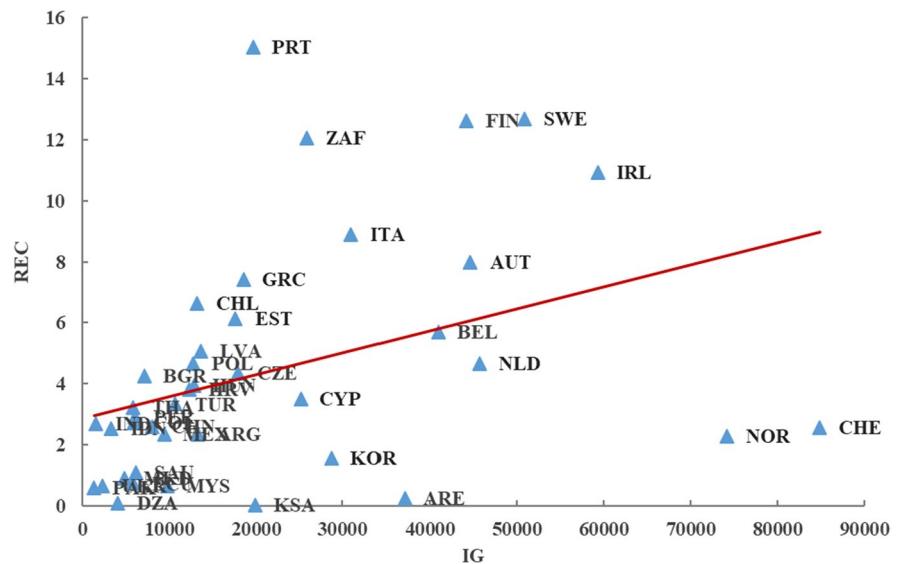
Appendix 2

Fig. 2 Financial inclusion (IFI) and inclusive growth (IG)



Appendix

Fig. 3 Renewable energy consumption (REC) and inclusive growth (IG)



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Declarations

Conflict of interest The authors declare no competing interests.

References

- Ahmed, M. M., & Shimada, K. (2019). The effect of renewable energy consumption on sustainable economic development: Evidence from emerging and developing economies. *Energies*, *12*(15), 2954.
- Ali, I., & Son, H. H. (2007). Measuring inclusive growth. *Asian Development Review*, *24*(1), 11.
- Ali, I., & Zhuang, J. (2007). Inclusive growth toward a prosperous Asia: Policy implications. ERD working Paper No. 97, Economics and Research Department, Asian Development Bank, Manila, 1–10.
- Anselin, L. (1988). Lagrange multiplier test diagnostics for spatial dependence and spatial heterogeneity. *Geographical Analysis*, *20*(1), 1–17.
- Apergis, N., & Danuletiu, D. C. (2014). Renewable energy and economic growth: Evidence from the sign of panel

long-run causality. *International Journal of Energy Economics and Policy*, *4*(4), 578–587.

- Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2011). Firm innovation in emerging markets: The role of finance, governance, and competition. *Journal of Financial and Quantitative Analysis*, *46*(6), 1545–1580.
- Berg, A. G., & Ostry, J. D. (2017). Inequality and unsustainable growth: Two sides of the same coin? *IMF Economic Review*, *65*(4), 792–815.
- Bildirici, M. E. (2014). Relationship between biomass energy and economic growth in transition countries: Panel ARDL approach. *Gcb Bioenergy*, *6*(6), 717–726.
- Chen, S. T., Kuo, H. I., & Chen, C. C. (2007). The relationship between GDP and electricity consumption in 10 Asian countries. *Energy Policy*, *35*(4), 2611–2621.
- Chenery, H. B. (1975). The structuralist approach to development policy. *The American Economic Review*, *65*(2), 310–316.
- Corak, M. (2013). Income inequality, equality of opportunity, and intergenerational mobility. *Journal of Economic Perspectives*, *27*(3), 79–102.
- Corrado, G., & Corrado, L. (2017). Financial inclusion for inclusive growth and development. *Current Opinion in Environmental Sustainability*, *24*, 19–23.
- Dabla-Norris, E., Ji, Y., Townsend, R. M., & Unsal, D. F. (2021). Distinguishing constraints on financial inclusion and their impact on GDP, TFP, and the distribution of income. *Journal of Monetary Economics*, *117*, 1–18.
- Dixit, R., & Ghosh, M. (2013). Financial inclusion for inclusive growth of India-A study of Indian states. *International Journal of Business Management & Research*, *3*(1), 147–156.

- Dupas, P., & Robinson, J. (2013). Savings constraints and microenterprise development: Evidence from a field experiment in Kenya. *American Economic Journal: Applied Economics*, 5(1), 163–192.
- Fankhauser, S., & Jotzo, F. (2018). Economic growth and development with low-carbon energy. *Wiley Interdisciplinary Reviews: Climate Change*, 9(1), e495.
- Farhana, D. K. M., Rahman, S. A., & Rahman, M. (2012). Factors of migration in urban Bangladesh: An empirical study of poor migrants in rahshahi city. *Bangladesh e-Journal of Sociology*, 9(1), 63–86.
- Han, J., & Shen, Y. (2015). Financial development and total factor productivity growth: Evidence from China. *Emerging Markets Finance and Trade*, 51(sup1), S261–S274.
- Ji, X., Wang, K., Xu, H., & Li, M. (2021). Has digital financial inclusion narrowed the urban-rural income gap: The role of entrepreneurship in China. *Sustainability*, 13(15), 8292.
- Kapoor, A. (2014). Financial inclusion and the future of the Indian economy. *Futures*, 56, 35–42.
- Kim, J. H. (2016). A study on the effect of financial inclusion on the relationship between income inequality and economic growth. *Emerging Markets Finance and Trade*, 52(2), 498–512.
- King, R. G., & Levine, R. (1993a). Finance and growth: Schumpeter might be right. *The Quarterly Journal of Economics*, 108(3), 717–737.
- King, R. G., & Levine, R. (1993b). Finance, entrepreneurship and growth. *Journal of Monetary Economics*, 32(3), 513–542.
- Kouton, J. (2021). The impact of renewable energy consumption on inclusive growth: Panel data analysis in 44 African countries. *Economic Change and Restructuring*, 54(1), 145–170.
- Lee, J. W. (2019). Long-run dynamics of renewable energy consumption on carbon emissions and economic growth in the European Union. *International Journal of Sustainable Development & World Ecology*, 26(1), 69–78.
- Lesage, J. P., & Pace, R. K. (2009). *Introduction to spatial econometrics*. RC Press.
- Levine, R. (2005). Finance and growth: Theory and evidence. *Handbook of Economic Growth*, 1, 865–934.
- Maji, I. K. (2015). Does clean energy contribute to economic growth? Evidence from Nigeria. *Energy Reports*, 1, 145–150.
- Maji, I. K., Sulaiman, C., & Abdul-Rahim, A. S. (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. *Energy Reports*, 5, 384–392.
- Marinas, M. C., Dinu, M., Socol, A. G., & Socol, C. (2018). Renewable energy consumption and economic growth Causality relationship in Central and Eastern European countries. *PloS One*, 13(10), e0202951.
- Mushtaq, R., & Bruneau, C. (2019). Microfinance, financial inclusion and ICT: Implications for poverty and inequality. *Technology in Society*, 59, 101154.
- McKinley T. 2010. Inclusive growth criteria and indicators: An inclusive growth index for diagnosis of country progress.
- Nizam, R., Karim, Z. A., Rahman, A. A., & Sarmidi, T. (2020). Financial inclusiveness and economic growth: New evidence using a threshold regression analysis. *Economic Research-Ekonomika Istraživanja*, 33(1), 1465–1484.
- Ohene-Asare, K., Tetteh, E. N., & Asuah, E. L. (2020). Total factor energy efficiency and economic development in Africa. *Energy Efficiency*, 13(6), 1177–1194.
- Oluseye, I. C., & Gabriel, A. A. (2017). Determinants of inclusive growth in Nigeria: An ARDL approach. *American Journal of Economics*, 7(3), 97–109.
- Oyinlola, M. A., & Adediji, A. (2019). Human capital, financial sector development and inclusive growth in sub-Saharan Africa. *Economic Change and Restructuring*, 52(1), 43–66.
- Osmani M, El-Haddadeh R, Hindi N, Janssen M, & Weerakody V. (2020). Blockchain for next generation services in banking and finance: Cost, benefit, risk and opportunity analysis. *Journal of Enterprise Information Management*, 34(3).
- Raheem, I. D., Isah, K. O., & Adediji, A. A. (2018). Inclusive growth, human capital development and natural resource rent in SSA. *Economic Change and Restructuring*, 51(1), 29–48.
- Rauniyar, G., & Kanbur, R. (2010). Inclusive growth and inclusive development: A review and synthesis of Asian Development Bank literature. *Journal of the Asia Pacific Economy*, 15(4), 455–469.
- Sarma, M. (2015). Measuring financial inclusion. *Economics Bulletin*, 35(1), 604–611.
- Schmied, J., & Marr, A. (2016). Financial inclusion and poverty: The case of Peru. *Regional and Sectoral Economic Studies*, 16(2), 29–43.
- Silber, J., & Son, H. H. (2010). On the link between the Bonferroni index and the measurement of inclusive growth. *Economics Bulletin*, 30(1), 421–428.
- Song, Y., Zhang, X., & Zhang, M. (2021). The influence of environmental regulation on industrial structure upgrading: Based on the strategic interaction behavior of environmental regulation among local governments. *Technological Forecasting and Social Change*, 170, 120930.
- Sugiawan, Y., & Managi, S. (2019). New evidence of energy-growth nexus from inclusive wealth. *Renewable and Sustainable Energy Reviews*, 103, 40–48.
- Tella, S. A., & Alimi, O. Y. (2016). Determinants of inclusive growth in Africa: Role of health and demographic changes. *African Journal of Economic Review*, 4(2), 138–146.
- van Krevel, C. (2021). Does natural capital depletion hamper sustainable development? *Panel Data Evidence. Resources Policy*, 72, 102087.

- Xie, F., Liu, Y., Guan, F., & Wang, N. (2020). How to coordinate the relationship between renewable energy consumption and green economic development: From the perspective of technological advancement. *Environmental Sciences Europe*, 32(1), 1–15.
- Wang YL. (2021). Research on the relationship between green energy use, carbon emissions and economic growth in Henan province. *Frontiers in Energy Research*, 390.
- Zhe, L., Yüksel, S., Dinçer, H., Mukhtarov, S., & Azizov, M. (2021). The positive influences of renewable energy consumption on financial development and economic growth. *SAGE Open*, 11(3), 21582440211040132.
- Zhou, H., & Xu, G. (2022). Research on the impact of green finance on China's regional ecological development based on system GMM model. *Resources Policy*, 75, 102454.
- Zou, K., & He, J. (2018). Intra-provincial financial disparity, economic disparity, and regional development in China: Evidence from prefecture-level city data. *Emerging Markets Finance and Trade*, 54(13), 3064–3080.

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