Creating financial inclusion in "Belt and Road" countries in Europe, Asia and Africa: regulation, technology and financial literacy

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Abstract

Purpose – This study aims to comparatively measure the impact factors of financial inclusion and their spillover effects for Belt and Road countries using panel data from 57 countries in 2011, 2014, 2017 and 2021 and relevant indicators from three dimensions: availability, usage and quality to construct a digital empowerment index of financial inclusion.

Design/methodology/approach – A spatial Durbin panel model is constructed to empirically test the impact mechanism of financial inclusion under digital empowerment.

Findings – Results reveal that improving a country's quality of regulation, technology and residents' financial literacy significantly contributes to the development of its financial inclusion, while improving its neighboring countries' financial literacy also boosts its financial inclusion development. This study provides theoretical support for evaluating the development level of inclusive finance in "Belt and Road" countries, promoting the development of inclusive finance and alleviating the problem of financial exclusion.

Originality/value – This study is original as it creates a research paradigm for "Belt and Road" countries, enabling systematic testing and comparative analysis of inclusive finance development. It incorporates traditional and digital services, evaluating them based on sharing, fairness, convenience and specific group benefits. An inclusive financial index is constructed using the coefficient of variation and arithmetic weighted average methods. Additionally, it introduces a more rational analysis approach for the influence mechanism and spatial effect, using an economic geography nested matrix and spatial Durbin model to explore spatial effects in inclusive finance.

Keywords Financial inclusion, Influence mechanism, Belt and Road initiative, Regulation, Financial literacy, Financial exclusion, Neighboring county spillover

Paper type Research paper

1. Introduction

As global economic development improves, people are becoming increasingly concerned about social inequity and poverty, and poverty eradication has become a core long-term task of national governance. From an economic perspective, this problem reflects the contradiction between equity and efficiency, and financial inclusion was created to solve this contradiction. Promoting society's fair and harmonious development and alleviating and eliminating poverty are important connotations of financial inclusion (Fu, 2020).

The World Bank's Consultative Group to Assist the Poor (CGAP) has identified four dimensions of an inclusive financial system: demanders, financial institutions, financial infrastructure and services and the macro-policy environment (Emara and El Said, 2021). The "Belt and Road Initiative" advocates fair, harmonious and sustainable development and promotes deep cooperation between countries and financial institutions along the route. This ensures that low-income individuals who are financially excluded can enjoy the convenience of financial services while alleviating the difficulties of financing for micro-, small- and medium-sized enterprises (MSMEs), consistent with financial inclusion's inherent requirements. Inclusive finance directly or indirectly promotes upgrading the industrial structure, and improving residents' income helps narrow the gap between urban and rural financial services, accelerates the development of new financial services such as digital accounts and mobile payments and injects vitality into the "Belt and Road's" construction (Skålnes, 2021).

2. Literature review

"Belt and Road" countries constitute more than 60% of the world's population and are of great importance. A broad international platform, such as the "Belt and Road Initiative," is indispensable for studying the experiences of poverty alleviation and prosperity at the national level. Countries have accumulated experience and lessons in financial inclusion development, which are important for studying inclusive finance and the development of a "human community with a shared future" (Nugent and Lu, 2021). Studies on financial inclusion development in "Belt and Road" countries are divided into three types. First, some studies promote the construction of the "Belt and Road Initiative" using financial inclusion to lift low-income individuals in "Belt and Road" countries out of poverty, support MSMEs' healthy development, provide direct or indirect support for infrastructure development in countries along the route and increase such countries' export potential, especially in capital-intensive industries. Yu et al. (2020) found that the impact on the Association of Southeast Asian Nations and West Asian countries was greater than on other "Belt and Road" countries. Second, many studies concern the various problems in "Belt and Road" cooperation, such as the large capital gap; the fact that financial cooperation remains preliminary, cross-currency cooperation is difficult, and risk management needs improvement; and the lack of relevant policy protection (Gu et al., 2022). The third type of research concerns new financial development ideas in "Belt and Road" construction. These ideas consider the possible spatial correlation effect of inclusive finance among countries.

Conversely, they consider the serious obstacles posed to countries' trade interconnection owing to the large disparity in the economic structures of different countries spanning multiple continents and inconsistent financial clearing and settlement systems (Ma and Liu, 2020). Using the characteristics of blockchain technology, such as decentralization, interaction, coordination and sharing and time stamping, a more reasonable financial system can be built to provide new ideas for "Belt and Road" financial development. From the perspective of trade competition and complementarity, some scholars have noted that the GDP, trade complementarity and free trade agreements (FTAs) between China and countries along the route have significantly contributed to the development of trade between them and that improving the trade promotion policies of

countries along the route and expanding complementary industry cooperation are significant for each country's economic and financial development (Chen *et al.*, 2020; Yang *et al.*, 2022).

Limited research exists on the comparative measurement of the "Belt and Road"; however, inclusive finance's development-level measurement and index construction are relevant for such research. The early financial inclusion index consisted of two indicators: coverage and financial service usage (Beck *et al.*, 2007). With inclusive finance's continuous development and improvement, scholars have used the United Nations Development Program's Human Development Index's (HDI) construction method to comprehensively measure inclusive finance development in each country in three dimensions: the availability, usage and service quality of financial services (Bozkurt *et al.*, 2018; Dabla-Norris *et al.*, 2021; Sarma, 2016; Wang and Guan, 2017). Some scholars have creatively proposed that the Buffett index (stock market value/gross domestic product) should be used to measure the health of capital market development (Bittencourt, 2012), which could be improved in terms of financial service demand to make the inclusive financial index's (IFI) measurement range more comprehensive (Ambarkhane *et al.*, 2016). Scholars have further proposed that the government supply and infrastructure construction situation should be considered from different subjects' perspectives. This would reflect inclusive finance's development level comprehensively and render its measurement more accurate and reliable (Adegbite and Machethe, 2020).

Many factors influence inclusive finance development; therefore, this research has value for "Belt and Road" countries. The first factor is price; the most typical financial exclusion is price exclusion, by which low-income individuals are excluded because of financial institutions' high service prices. In this case, inclusive finance development requires reasonable fees that are affordable for poorer groups (Bester *et al.*, 2008; Noronha and Kumar, 2019). The second factor is service accessibility. Research has shown that convenient and fast financial services contribute significantly to inclusive finance development. For example, mobile banking can serve users 24/7, which not only broadens financial transactions but is also safe, convenient and inexpensive. Many financially excluded, low-income individuals can meet their personal needs using this digital approach (Bihari, 2011; Charles, 2019). The third factor is national financial regulation and residents' financial literacy. Empirical studies have found that national financial regulation policies have a significant impact on financial inclusion development; furthermore, factors such as residents' financial literacy and ability to use financial services significantly affect financial inclusion promotion in a country (Allen *et al.*, 2016). The final factor is the technology level. Studies show that a country's degree of technological development is closely related to financial inclusion. Furthermore, technological development has strongly promoted financial technology progress, constantly improving financial platform construction and the development of new financial inclusion products. This not only expands the coverage of financial inclusion and enhances commercial sustainability but also deepens financial inclusion's reach, bringing more convenient financial services to inclusive groups (Lashitew *et al.*, 2019).

Research on financial inclusion's development and impact mechanisms in "Belt and Road" countries remains insufficient. Although there are abundant findings regarding inclusive finance in these countries, there is a lack of impact mechanism analysis framework that is organically connected to empirical and practical analysis, which does not match the extensive, inclusive finance activities in "Belt and Road" countries. Moreover, although international institutions have gradually included digital finance elements in their financial inclusion measurement systems since 2016, a lack of corresponding index construction and empirical analysis at the international level remains, and research in individual countries has focused on new digital finance types in digital financial institutions. Thus, studies on traditional inclusive finance and modern digital inclusive finance are relatively isolated, and

indicator systems and comparative studies on the level of inclusive finance in the "Belt and Road" countries under the condition of digital empowerment are lacking. Furthermore, existing literature uses a general panel model for empirical analysis. Owing to inclusive finance's spatial spillover effect, the general panel model cannot reflect the data's spatial information; therefore, its research conclusions' reliability and accuracy still be discussed.

To compensate for the shortcomings of existing research while considering that the "Belt and Road Initiative" spans three continents (Europe, Asia and Africa) and is the world's largest economic belt encompassing several countries, this study takes 57 "Belt and Road" countries as research objects and advances three marginal contributions. First, constructing a relatively comparable research paradigm for the "Belt and Road" countries will enable comprehensive and systematic testing and comparative analysis, which can more accurately depict the inclusive finance development map in "Belt and Road" countries. Second, developing a measurement and evaluation system including both traditional and new forms of digital inclusive finance and considering sharing, fairness, convenience and benefitting specific groups can be used to measure inclusive finance's development level under digital empowerment more scientifically and comprehensively. Third, an economic-geographic nested matrix and the spatial Durbin model are used to explore financial inclusion's spatial effects to analyze influencing factors and spatial effects more rationally.

Less-developed financial service systems and socioeconomic environments are common in "Belt and Road" countries and will inevitably seriously hinder economic development. To alleviate employment problems, accelerate urban and rural transformations and support local industries conducive to economic development, inclusive finance development must be relied on. Policy opinions on inclusive finance construction are largely based on an in-depth discussion of inclusive finance's evaluation system and impact mechanism. These discussions provide a scientific basis and theoretical support for the scientific evaluation of financial inclusion development in countries along the route, promote financial inclusion development and alleviate financial exclusion to drive financial inclusion development and "Belt and Road" construction overall.

3. Theoretical analysis and research hypothesis

With continuous technological progress, inclusive finance relies on information technology, such as the internet and big data, to build new financial systems with sustainable and all-round characteristics. "Belt and Road" countries are economically connected and highly correlated regarding spatial distance, and inclusive financing may have regional diffusion of transmission characteristics. Per existing research, this study must fully consider the spatial correlation characteristics to analyze inclusive finance's spatial spillover effects and influencing factors more comprehensively. This study explores the factors influencing inclusive finance under digital empowerment from three perspectives: demand, supply and regulation.

3.1 Demand

Financial literacy measures residents' understanding and application of financial knowledge, which is necessary for making reasonable financial decisions and improving personal wealth. Understanding financial literacy contributes to inclusive groups' decision-making process, enabling them to carefully evaluate different financial products, select the right financial services, increase their creditworthiness through appropriate debt management skills and master risk-reduction strategies, such as purchasing insurance and saving accumulation. Financial literacy significantly affects financial inclusion development. The higher a country's financial literacy, the better it is for its residents to learn and apply financial knowledge and

access financial products and services to improve their standard of living, promoting financial inclusion (Allen *et al.*, 2016).

Continuous technological development has enabled financial institutions to develop digital financial products suitable for inclusive groups, reducing financial service transaction costs and enhancing financial services' reach through the internet and other means to positively impact financial inclusion promotion. This process cannot be achieved without improving the population's financial literacy; otherwise, it is difficult to achieve synergies effectively, as confirmed by South African and Indian survey data (Charles, 2019; Vijayvargy and Bakhshi, 2018). Because vulnerable groups often lack digital technology knowledge and skills, if inclusive groups' financial literacy is not improved, digital financial products driven by scientific and technological levels will aggravate the digital divide and financial exclusion (Adegbite and Machethe, 2020). Therefore, we hypothesize:

H1. Financial literacy has a significant positive effect on financial inclusion.

3.2 Supply

Technological advances have promoted the construction of a modern financial supply and service system, generated more financial service scenarios, enhanced financial inclusion coverage and deepened financial services' reach by effectively reducing their cost, allowing low-income people in remote areas to enjoy the convenience of financial services and improve their lives (Adegbite and Machethe, 2020). Technological advances have also helped financial institutions provide MSMEs better services, thus improving the difficult and costly situations they face. Technologies such as big data can be used by financial institutions for precision marketing and continuously tracking funds, providing full lifecycle financial services for MSMEs.

Advances in technology have driven digital finance's progress, which relies on new scientific technologies, such as big data and cloud computing; furthermore, digital finance's flourishing development has solved many drawbacks of traditional finance (Kouladoum *et al.*, 2022). Recently, traditional financial institutions have adopted digital finance service models to develop new financial products, and some scholars have studied technology, such as blockchain technology, to establish a new financial ecosystem to meet low-income people's specific needs and accurately match inclusive groups' suitability and the corresponding financial services. The results show that new financial products brought about by scientific and technological development can help address the digital divide. This has positive implications for inclusive financing development in various countries (di Prisco and Strangio, 2021). Thus, we hypothesize:

H2. The technology level has a significant positive effect on financial inclusion.

3.3 Regulators

As finance becomes increasingly important, higher requirements have been proposed for supervision level and regulation quality to ensure the financial system's safety and stability. To be sustainable, financial markets' effective functioning requires rules and regulations to constantly adapt to facilitate information and service provision and reduce transaction costs for participants. Financial inclusion's continued development requires a stable macroeconomic environment that cannot be supported without regulatory levels (Johnson, 2013).

By exploring the relationship between financial regulation quality and financial inclusion in Kenya, scholars have studied financial inclusion development and determined

that sophisticated financial regulations regulate financial access mechanisms. Considering the hidden and highly contagious nature of information technology risks and the "long tail" risks of inclusive finance, the lack of effective supervision can significantly violate the inclusive financial community's rights (Kodongo, 2018). Research has shown that improving regulation quality can help regulate the financial industry and reduce the risks the financial system faces. Digital infrastructure construction often requires high capital investment, and if the costs are not effectively covered, the inclusive finance supplier will inevitably be less motivated, requiring the government to solve negative externalities through national policy guidance and provide support to ensure commercial sustainability (Kouladoum *et al.*, 2022). Thus, we hypothesize:

> *H3.* Regulatory quality has a significant positive effect on financial inclusion.

4. Construction and measurement of inclusive financial index system for "belt and road" countries

4.1 Selection of indicators and data sources

Because inclusive finance's rich connotations, its index system usually has multiple dimensions. This study followed four principles when compiling the index. First, we correlated indicator selection: we selected indicators that comprehensively reflect inclusive finance's development level. Second, we reflected on inclusive financing's comprehensiveness. The selection of dimensions and indicators should allow for examining inclusive finance as comprehensively as possible from different perspectives and consider traditional and digital finance characteristics to build an indicator system that can quantify the abstract concept of inclusive finance in terms of digital empowerment. Third, we considered data availability. Owing to differences in inclusive finance development levels among countries worldwide, some countries' index data are insufficient. Considering the subsequent comparative analysis of the IFI, countries with more data should be selected when possible to facilitate comparative research. Finally, the results' readability was assessed. Inclusive finance is a broad and specific practice, not an empty theory, and the IFI compilation results should be intuitive and clear.

This study uses Song *et al.*'s (2020) research findings and *The G20 Financial Inclusion Index* to calculate the relevant indicators in the dimensions of accessibility, usage and quality for 57 "Belt and Road" countries in 2011, 2014, 2017 and 2021. The data were derived mainly from Global Findex provided by the World Bank and the Financial Access Survey provided by the International Monetary Fund.

The indicator composition is shown in Supplementary Table SI.

4.2 Determination of weights

Following Xiao and Hong (2014), this study uses the coefficient of variation to determine each indicator's weight in the financial inclusion index. The variation method's coefficient was originally used in probability theory and statistics to measure dispersion in probability distribution or frequency distribution, which is the ratio of the standard deviation to the mean. If an indicator's degree of variation is large, it suggests that the indicator has stronger explanatory power for the overall financial inclusion index, and it should be given greater weight. The formulas are as follows:

$$v_i = \frac{\sigma_i}{\overline{x}_i} \tag{1}$$

$$w_i = \frac{v_i}{\sum v_i} \tag{2}$$

where v_i represents variation coefficient, σ_i the standard deviation, $\bar{x}_i$ the mean value and w_i each indicator's weight.

4.3 Standardization of indicators

This study refers to Sarma's (2016) method of standardizing indicators by subtracting the indicator's smallest value for each country, dividing it by each indicator's largest difference and multiplying it by the corresponding weight to obtain each indicator's value. Standardized data are more realistically reflect the actual situation. The higher the value of the indicator, the higher its level of financial inclusion. The basic formulas are as follows:

$$x_i = \frac{A_i - m_i}{M_i - m_i} \tag{3}$$

$$d_i = w_i x_i \tag{4}$$

where A_i are the respective indicators' values, and x_i is each indicator's value after $Max - Min$ normalized values. M_i and m_i represent each indicator's maximum and minimum values, and w_i are their weights. Standardized indicators take values between 0 and 1.

4.4 Inclusive financial index synthesis

Drawing on Sarma's (2016) method of constructing a financial inclusion index, we use point X in an N-dimensional Cartesian coordinate system, with $X = (d_1, d_2 \ldots d_n)$ denoting a country's inclusive finance development level, $O = (0, 0 \ldots 0)$ representing the country with the worst financial inclusion development level, and $W = (w_1, w_2 \ldots w_n)$ representing the country with the best financial inclusion development level. Let the Euclidean distance between X and O be X_1, that between X and W be X_2 and the *IFI* be the arithmetic mean of X_1 and X_2. The formulas are as follows:

$$X_1 = \frac{\sqrt{d_1^2 + d_2^2 + \ldots + d_n^2}}{\sqrt{w_1^2 + w_2^2 + \ldots + w_n^2}} \tag{5}$$

$$X_2 = 1 - \frac{\sqrt{(w_1 - d_1)^2 + (w_2 - d_2)^2 + \ldots + (w_n - d_n)^2}}{\sqrt{w_1^2 + w_2^2 + \ldots + w_n^2}} \tag{6}$$

$$IFI = \frac{X_1 + X_2}{2} \tag{7}$$

Supplementary Table SII reports "Belt and Road" countries' IFI measurement and ranking, which overall shows an upward trend for most "Belt and Road" countries, mostly between 0.2 and 0.4. Referring to Sarma's (2016) criteria for classifying the international financial inclusion development level, $0 < IFI < 0.3$ indicates low inclusive financial development,

0.3 < *IFI* < 0.6 indicates a medium financial inclusion development level and 0.6 < *IFI* < 1 indicates high financial inclusion development.

Per the 2021 Financial Inclusion Index, most "Belt and Road" countries have relatively low financial inclusion development, and there is a large gap in financial inclusion levels. For countries with higher economic levels, such as Russia, Singapore and Cyprus, the financial inclusion index is generally higher than 0.6, reflecting that they have greater financial inclusion development, and their development experience should be considered by countries such as China, Greece, Bahrain, Bulgaria and Croatia, who are in the middle. However, some countries perform well in some aspects, such as China and Greece, with index levels close to 0.6, close to the leading level. Other countries, such as Indonesia, Kenya and Bangladesh, perform well in the use of financial inclusion. Thirty-one countries are in the lagging category – in the lower reaches of the three dimensions of accessibility, usage and quality – and have much room for improvement.

5. Analysis of financial inclusion's impact mechanism in "Belt and Road" countries

5.1 Data source and indicator selection

This study empirically analyzes panel data from 57 "Belt and Road" countries for 2011, 2014, 2017 and 2021. The financial inclusion index was calculated. The other variables' data source was the World Bank database.

5.1.1 Explanatory variables. In this study, the IFI is the explained variable, calculated according to the compilation method of the financial inclusion index established above. Various countries' financial inclusion level is comprehensively reflected in the three dimensions of availability, use and quality.

5.1.2 Explanatory variables. Referring to Lashitew *et al.* (2019), financial literacy (Literacy), technology and regulation quality were explanatory variables. Financial literacy affects the population's understanding of financial knowledge and is measured by gross enrollment in higher education. Technology is essential for digitally enabled financial inclusion, and patents are often closely related to a country's technological development, as measured by the natural logarithm of the number of patents filed by residents. Financial development cannot be achieved without regulation specification or improvement as measured by regulatory quality assessment.

5.1.3 Control variables. Wang and Guan (2017) and Bozkurt *et al.* (2018), we used several control variables. Age: Countries face differences in aging, and most older adults are not good at using mobile phones, computers and other technological products, which may impact the financial inclusion level under digital empowerment, as measured by the proportion of the population aged 65 years and above in the total population. Digitization: Digitization is the integration of traditional financial services through digital means and is measured by the proportion of services purchased using digital means in the past year. Gross national income (GNI; Income): The natural logarithm of GNI per capita, measured by purchasing power parity (PPP), is closely related to a country's economic level. Capital ratio (CAR): This reflects commercial banks' capital measured as a proportion of their total assets. Social stability (Stability): A stable social environment contributes to a country's economic and financial performance as measured by political stability assessment and the absence of terrorism. Urbanization: The urbanization level is closely related to economic development and is measured as the ratio of the urban population to the total population. The specific measurements for each variable are listed in Table 1.

Variable name	Variable symbols	Measurement
Financial inclusion index	IFI	Based on the IFI compilation above
Financial literacy	Literacy	Gross enrollment ratio in tertiary education
Technology level	Technology	Natural logarithm of the number of patent applications filed by residents
Regulatory quality	Quality	Assessment of supervision quality
Digital finance	Digitization	Proportion of services purchased using digital methods in the past year (%)
Gross national income per capita	Income	Natural logarithm of GNI per capita in purchasing power parity terms
Age	Age	Proportion of population aged 65 years and over to total population (%)
Urbanization rate	Urbanization	Urban population as a proportion of total population (%)
Capital ratio	CAR	Commercial banks' capital as a percentage of total assets (%)
Social stability	Stability	Political stability and absence of terrorism assessment

Notes: IFI = Inclusive finance index; GNI = gross national income
Source: Authors' own creation

Table 1.
Definition of key
variables

5.2 Study design
5.2.1 Spatial autocorrelation judgment. Because of the distance differences among countries and the explanatory variable's (financial inclusion index) strong spatial mobility, the possible spatial correlation of various countries' financial inclusion index must be tested before conducting an empirical study. The main judgment indices were Geary's C and Moran's indices. Referring to existing literature, this study used the Moran index to test spatial autocorrelation:

$$Moran's \ I = \frac{\sum_{i=1}^{n}\sum_{i\neq j}^{n}W_{ij}(Y_i - \overline{Y})(Y_j - \overline{Y})}{S^2\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}} \tag{8}$$

Y_i and Y_j denote the observations of the ith and jth countries, that is, the financial inclusion index; n the number of countries; and W_{ij} the elements in an economic-geographic nested matrix that has zero elements on the diagonal, rows and columns corresponding to spatial cells. In general, the global Moran's index is between -1 and 1. When the global Moran's index lies between 0 and 1, the sample is positively correlated in the spatial dimension, that is, each country's financial inclusion index shows low values clustered with low values and high values clustered with high values. Conversely, the sample is negatively correlated in the spatial dimension, showing low values clustered with high values.

The Moran's index of the IFI was measured first; the global Moran's index by year is shown in Table 2. The Moran index is always positive during the observation period (2011–2021). Therefore, the financial inclusion index's spatial distribution is either a clustering of high values with high values or a clustering of low values with low values.

5.2.2 Model design.

$$IFI = \lambda WIFI + X\beta + WX\delta + \varepsilon \tag{9}$$

W is a matrix of spatial weights reflecting the spatial linkages among different countries, β is the parameter to be estimated and δ is the corresponding coefficient vector. ε is the model's error term. The spatial weight matrix was used to construct the economic-geographic nested matrix for the analysis based on Yang *et al.*'s (2022) findings.

5.2.2.1 Geographical distance matrix.

$$W_{ij} = \{ \begin{array}{l} \frac{1}{d_{ij}^2}, i \neq j \\ 0, i = i \end{array} \tag{10}$$

d_{ij} indicates the distance between countries calculated from their latitude and longitude. The closer countries are geographically, the more spatially connected they are.

5.2.2.2 Economic geography nested matrix.

$$W_{ij} = \{ \begin{array}{l} W_d \times diag\left(\frac{\overline{GDP_1}}{\overline{GDP}}, \frac{\overline{GDP_2}}{\overline{GDP}}, \ldots, \frac{\overline{GDP_n}}{\overline{GDP}}\right), i \neq j \\ 0, i = i \end{array} \tag{11}$$

W_{ij} is the geographic matrix in equation (10). $\overline{GDP}_n$ denotes the nth country's mean GDP, and $\overline{GDP}$ denotes all countries' mean GDP value. The economic-geographic nested matrix considers each country's geospatial factors and economic characteristics to better describe the combined spatial linkages.

6. Baseline analysis and results

6.1 Descriptive statistics

6.1.1 Descriptive statistics of variables. Table 3 reports the variables' descriptive statistical results; the financial inclusion index's mean value is 0.287, and the standard deviation is 0.144, with minimum and maximum values of 0.046 and 0.677. This reflects the disparity in "Belt and Road" countries' financial inclusion development and shows that most countries have low development levels.

6.2 Baseline test results

When considering which spatial model to use, Wald and LR tests can be used to determine whether the SDM can be simplified to the SEM and SLM models. According to the results, the original hypothesis is that the SDM model degenerates into an SLM model, and an SEM model is rejected, that is, the SDM model cannot degenerate into an SLM or SEM model.

Year	Moran index	Expectations	Standard deviation	z-value	p-value
2011	0.028	−0.018	0.028	1.634	0.051
2014	0.025	−0.018	0.028	1.559	0.060
2017	0.027	−0.018	0.028	1.608	0.054
2021	0.019	−0.018	0.028	1.323	0.093

Source: Authors' own creation

Table 2.
Global Moran index test results

Therefore, the SDM model was chosen for the regression analysis. For spatial panel data, which model is suitable for analysis must be determined. Generally, fixed- and random-effects models are used for spatial panel data. In this study, the Hausman test was used to determine whether to choose a random- or fixed-effects model. The Hausman test value was 38.41, and the p-value was 0. Therefore, the random effects model's null hypothesis was rejected, and the fixed effects model was used.

Table 4 presents the SDM regression results. Technology level's and financial literacy's regression coefficients are both significantly positive at the 1% level, indicating that technology level and financial literacy significantly contribute to financial inclusion.

Variables	No.	Average value	Standard deviation	Minimum value	Maximum value
Financial inclusion index	228	0.287	0.144	0.046	0.677
Regulatory quality	228	0.208	0.806	−1.827	2.118
Financial literacy	228	0.365	0.101	0.088	0.615
Technology level	228	5.132	2.561	0.693	13.594
Digital finance	228	0.230	0.204	0.009	0.705
Gross national income per capita	228	9.595	0.925	7.645	11.537
Age	228	0.092	0.061	0.009	0.217
Urbanization rate	228	0.588	0.215	0.182	1.000
Capital ratio	228	0.108	0.034	0.043	0.193
Social stability	228	−0.365	1.003	−2.801	1.191

Source: Authors' own creation

Table 3.
Descriptive statistics
of variables

Variables	Coefficient	Standard error	z-value	p-value
Technology level	0.023***	0.004	6.070	0.000
Regulatory quality	0.018**	0.009	2.090	0.037
Financial literacy	0.246***	0.053	4.660	0.000
Age	−0.107	0.261	−0.410	0.683
Urbanization rate	0.148	0.124	1.190	0.235
Capital ratio	−0.060	0.080	−0.750	0.451
Social stability	−0.004	0.006	−0.720	0.473
Digital finance	0.122	0.330	0.370	0.711
Gross national income per capita	0.007	0.012	0.560	0.578
W × level of technology	0.029	0.025	1.160	0.246
W × regulatory quality	0.026	0.084	0.310	0.755
W × financial literacy	0.850***	0.323	2.630	0.009
W × age	−0.527	0.878	−0.600	0.548
W × urbanization rate	0.120	0.465	0.260	0.797
W × capital ratio	0.400	0.646	0.620	0.536
W × social stability	−0.120***	0.037	−3.210	0.001
W × digital finance	−3.896***	1.406	−2.770	0.006
W × Gross national income per capita	0.265***	0.065	4.060	0.000
Observations	228			
R^2	0.228			

Notes: ***, ** and * represent 1, 5 and 10% significance levels, respectively
Source: Authors' own creation

Table 4.
Spatial Durbin model
estimation results

Regulatory quality's regression coefficient is significantly positive at the 5% level, indicating that regulatory quality significantly contributes to financial inclusion improvement. Therefore, *H1*, *H2* and *H3* are valid. The part containing W measures the independent variables' impact in neighboring regions on the region's financial inclusion development during the data observation period. The improvement of scientific and technological levels and regulatory quality in neighboring countries has no significant impact on other neighboring countries' inclusive finance development; however, the influence coefficient of financial literacy in neighboring countries on other neighboring countries' inclusive finance is significantly positive at the 1 % level. Therefore, improvements in neighboring countries' financial literacy also positively impact other neighboring countries' inclusive finance development.

Considering that each variable's marginal effects on financial inclusion cannot be obtained based only on these SDM regression results, to further investigate the spatial effects among variables, inclusive finance's direct and indirect effects are decomposed using LeSage's spatial measurement partial differential method. The direct effect reflects the influence of each variable in the country on the IFI, whereas the indirect effect reflects the influence of each variable in neighboring countries on the IFI in the country, with the total effect being the sum of the direct and indirect effects.

Table 5 presents the SDM's decomposition results. According to the direct effects' decomposition results, technology level's and financial literacy's coefficients are significantly positive at the 1% level, indicating that a country's technology level and financial literacy improvement significantly contribute to financial inclusion development. Regulatory quality's coefficient is significantly positive at the 5% level, indicating that its improvement in a country can promote financial inclusion development. This indicates that improving a country's regulation quality can promote inclusive financing development. According to the indirect effect's decomposition results, financial literacy's coefficient is significantly positive at the 10% level, indicating that a country's neighbors' financial literacy improvement will promote financial inclusion development in their own country, aligning with the SDM regression results above.

6.3 Robustness test

This study conducts a robustness test by replacing the IFI's synthesis method. The model passes the robustness test if the regression results thereof remain consistent with the spatial Durbin model's regression analysis above. In the IFI synthesis step, three dimensions' of IFI,

	Direct effects		Indirect effects		Total effect	
Variables	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value
Technology level	0.023***	5.760	0.002	0.190	0.025**	1.970
Regulatory quality	0.017**	2.360	0.001	0.030	0.018	0.410
Financial literacy	0.233***	4.200	0.298*	1.670	0.531***	3.090
Age	−0.072	−0.240	−0.306	−0.550	−0.378	−0.890
Urbanization rate	0.123	0.790	0.035	0.120	0.158	0.740
Capital ratio	−0.067	−0.810	0.256	0.790	0.189	0.600
Social stability	−0.000	−0.070	−0.062***	−3.060	−0.063***	−3.390
Digital finance	0.180	0.560	−2.034**	−2.520	−1.853**	−2.280
Gross national income per capita	−0.001	−0.100	0.138***	3.640	0.137***	4.000

Table 5.
Spatial Durbin model effect decomposition

Notes: ***, ** and * represent 1, 5 and 10% significance levels, respectively
Source: Authors' own creation

namely, availability, usage and quality, is calculated first. The method of synthesizing the IFI from the three dimensions is consistent with the above method of calculating it.

Table 6 presents the robustness test results. Technology level's and financial literacy's regression coefficients are significantly positive at the 1% level, and regulatory quality's is also significantly positive at the 5% level, indicating that improving technology level, regulatory quality and financial literacy has a positive impact on financial inclusion development, consistent with the spatial Durbin model results. This study's findings are thus highly robust.

7. Discussion and conclusions

The COVID-19 pandemic's continued impact has led to a global economic downturn, with MSMEs and low-income individuals facing an even more severe survival crisis, causing countries worldwide to launch financial inclusion policies to help economic recovery.

7.1 Conclusion

This study refers to *The G20 Financial Inclusion Index*, selects relevant indicators from the three dimensions of availability, usage and quality, conducts dimensionless processing and constructs a financial inclusion index for 57 "Belt and Road" countries in 2011, 2014, 2017 and 2021 using the coefficient of variation and weighted average methods.

First, there are obvious disparities among countries' financial inclusion development. Per the IFI cluster analysis results, countries are divided into three categories: leading, uneven and lagging. There are wide gaps among "Belt and Road" countries' inclusive finance levels, reflecting that more economically developed countries are far ahead of economically less-

Variables	Coefficient	Standard error	z-value	p-value
Technology level	0.022***	0.005	4.600	0.000
Regulatory quality	0.021**	0.011	1.960	0.050
Financial literacy	0.277***	0.066	4.180	0.000
Age	−0.485	0.329	−1.470	0.141
Urbanization rate	0.004	0.157	0.030	0.979
Capital ratio	−0.172*	0.102	−1.690	0.092
Social stability	−0.003	0.007	−0.400	0.688
Digital finance	0.500	0.416	1.200	0.230
Gross national income per capita	−0.007	0.015	−0.450	0.656
W × level of technology	−0.007	0.031	−0.220	0.825
W × regulatory quality	0.069	0.105	0.650	0.514
W × financial literacy	0.005	0.369	0.010	0.988
W × age	−5.275	1.243	−4.240	0.000
W × urbanization rate	−0.475	0.582	−0.820	0.414
W × capital ratio	−1.012	0.867	−1.170	0.243
W × social stability	−0.101	0.045	−2.240	0.025
W × digital finance	4.841	2.049	2.360	0.018
W × gross national income per capita	0.426	0.085	5.020	0.000
Observations	228			
R^2	0.174			

Notes: ***, ** and * represent 1, 5 and 10% significance levels, respectively
Source: Authors' own creation

Table 6.
Robustness test results

developed countries regarding financial inclusion development and their development models and experiences are worth learning from.

Second, financial literacy has a positive effect on financial inclusion. Building a spatial panel Durbin model for regression showed that residents' financial literacy significantly contributes to their own countries' inclusive finance development, while financial literacy improvement in neighboring countries also has a positive effect on their country's inclusive finance development. This reflects the spatial spillover effect brought about by people's mobility. Financial literacy plays a positive moderating role in digital finance's impact on inclusive finance.

Third, the technology level has a significant positive impact on "Belt and Road" countries' financial inclusion development, which can be transmitted by increasing the digital finance level.

Fourth, improving regulation quality could help develop inclusive financing. The continuous improvement in regulatory quality helps the country form a well-regulated development environment, which significantly contributes to financial inclusion improvement. Further, regulation quality can also be transmitted to financial inclusion by increasing positive externalities.

7.2 Policy implications

Inclusive finance development is of great significance to economic prosperity, and this study's findings provide a reference for inclusive finance development.

First, there are obvious differences in "Belt and Road" countries' inclusive finance development; therefore, we can learn from their strengths and complement their weaknesses. Most countries in the leading IFI position are those with higher economic levels, reflecting that more economically developed countries are further ahead of economically less-developed countries regarding inclusive finance development, and their development models and experiences are worth learning from. Countries with uneven development have average IFI performances. Countries should improve their technology, legal systems and financial supervision to promote sustainable, inclusive financial development. Thirty-one countries lagged regarding financial inclusion development. These countries are in the lower reaches of the three dimensions of accessibility, usage and quality and have much room for improvement, which should arouse national governments' attention.

Second, countries should strengthen financial publicity and popularize financial education. Financial literacy affects financial inclusion development and is a significant moderating variable in the transition from technological empowerment to inclusive financial development. Improving residents' education level helps popularize financial literacy, expands financial product and service coverage, promotes consumers' financial literacy in various countries and enhances financial literacy and capability, which positively affects the smooth development of global inclusive finance. With digital empowerment, digital financial literacy's popularization, especially education on financial consumer knowledge in lagging countries, will provide strong support for the smooth and effective development of digital inclusive finance worldwide. Countries should popularize digital inclusive finance's prospects and convenience through different channels to improve residents' financial literacy and help them gradually access and use digital financial products.

Third, science and technology must be developed to support financial inclusion. Technology has played a significant role in the development of inclusive finance, with increasing technology levels driving digital innovation and digital models, increasing financial service accessibility while reducing transaction costs. This leads to more comprehensive development of inclusive finance and increased access to inclusive finance for residents. Digitization can address many barriers to financial inclusion by improving residents' financial literacy and establishing formal financial records. Mobile phone interface design can be

adapted to "Belt and Road" countries' environments. Some "Belt and Road" countries are economically less developed, with many low-income groups and low levels of education; mobile phone interfaces can be designed such that users can complete financial services by clicking an icon. Governments should actively explore financial systems, service channels and service model innovations; extend financial services' radiation radius; and continuously improve financial services' coverage and accessibility. Through technological means, more social capital should be mobilized to serve MSMEs and low-income individuals more precisely, promoting sustainable, inclusive, financial development.

Fourth, policymakers should establish a sound regulatory system and strengthen government policy support. As economic development and gross national income per capita increase, higher demand is placed on government regulations. Government regulations and policy support can significantly enhance digitally empowered inclusive financing. Effective regulation can regulate financial services, prevent financial risks and provide low-income groups with necessary protection, promoting inclusive finance development. Digitally enabled inclusive finance brings risks and challenges to information security while providing a wider range of financial services. Countries must establish effective information security protection mechanisms, use scalable data and advanced technology to improve supervision effectiveness and adaptability, strengthen communication and interaction between practitioners and regulatory authorities and establish a proven regulatory system. Simultaneously, external policy support should be strengthened to encourage beneficial innovation and orderly competition to comprehensively promote inclusive finance development.

7.3 Research deficiencies and prospects

Due to some "Belt and Road" countries' lack of data, only 57 were selected to ensure the integrity and continuity of the sample data set. As the "Belt and Road Project" continues to advance and national statistical data improves, future research results will be more accurate.

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Supplementary materials

The supplementary materials for this article can be found online.

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