

Research On the Coupling and Coordination Mechanism of Digital Development and Inclusive Finance

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Abstract. Digital development and inclusive finance are two important factors to promote the development of the national economy and high-quality economic growth. Exploring the coupling and impact mechanism between the two is of great practical significance for achieving sustainable development and common prosperity of the country. Based on this, this paper first takes the provincial economic panel data of China from 2013 to 2020 as the research object, considers the volatility and correlation of the indicators, uses the entropy method and critic method to calculate the combined weight, and measures the digital development index and inclusive finance index through the comprehensive index method. Then, analyzing the differences in the development levels of digitization and inclusive finance in various regions over time. Then, the coupling and coordination degree model is used to measure the coordinated development degree between the two systems. Finally, by using the two-way fixed effects model based on clustering standard errors, the impact mechanism of digital development level on inclusive finance and its components is investigated. The empirical results show that: from 2013 to 2020, the comprehensive scores of China's digital development level and inclusive finance level continued to improve, and the development differences between regions decreased, and the average coupling and coordination degree of digital development and inclusive finance continued to rise. In addition, the digital development level has a significant promoting effect on inclusive finance and all its aspects. In addition, based on the conclusions of this paper, from the perspective of digital development and inclusive finance development, this paper puts forward relevant policy suggestions for the high-quality development of China's economy.

Keywords: Digital Development Level, Inclusive Finance, Composite Index Method, Fixed Effects Model.

1. Introduction

China values the advancement of digital technology highly, and has proposed the Digital China strategy, and clearly stipulated the deployment of accelerating digital development in future development plans. This move highlights the core position of digitalization in social development, and firmly demonstrates China's determination to promote scientific and technological progress and innovation development[1]. At present, the rapid development of the digital economy and digital technology has continuously improved the level of China's digital development, and promoted the goal of building a socialist modernized country in all respects. High-quality development of the country cannot be separated from economic construction. In economic construction, inclusive finance plays an important role, which can provide support and guarantee for economic construction and promote the sustainable development of economic construction. Therefore, studying the coupling and coordinated development of digital development and inclusive finance, and putting forward personalized policy suggestions for different regions, is of great significance for promoting the common development of all provinces and achieving common prosperity.

The level of digital development varies in different regions. In terms of the coordinated development of digital development and inclusive finance, there are differences in the level of digital development in foreign countries. Developed countries such as the United States and Europe are leading in digital technology and applications, with a large scale of the digital economy and deepening digital transformation in various fields. Inclusive finance can help enterprises in various countries achieve digital transformation and sustainable development through innovative financial products and

service models[2], and promote the development and cooperation of the global digital economy. Developing countries are also actively promoting digital development, strengthening infrastructure construction, improving the popularity of digital technology, and promoting the development of the digital economy. In China, the level of digital development is continuously improving, the scale of the digital economy is gradually expanding, and inclusive finance also provides financial solutions for many enterprises, supporting their digital transformation and business development[3], providing professional financial support for customers, and helping enterprises achieve sustainable development. At the same time, under the support of China's policies[4], domestic enterprises are paying more and more attention to digital transformation, increasing investment in digital technology, improving production efficiency and service quality. Generally speaking, the level of digital development and inclusive finance are in a continuous stage of development and improvement. Digital transformation will continue to be an important direction for economic development in various countries, and financial services will play a key role in digital transformation, providing support and guarantee for enterprises and organizations.

In summary, domestic and foreign existing research has linked digital development and finance, and has conducted a large number of theoretical and practical studies. However, most scholars' research focuses on the promotion of finance by digital development alone, and the study of the coordinated development of digital development and inclusive finance is relatively blank. Both are related in reality, and the coordinated development of different regions will vary, resulting in the need for personalized policy construction. Based on this, this paper proposes new measurement methods for the digital development index and inclusive finance development index, and measures the two systems using the entropy value method and critic method. Secondly, conducting a heterogeneity analysis to observe the gap changes over time in different regions. Subsequently, this paper studied the coupling and coordinated development of digital development and inclusive finance, explored the changes in the coupling and coordinated degree of the two in different times and regions, and put forward differentiated policy suggestions.

2. Research principles and methods

2.1. Research principles

The concept of digital inclusive finance was proposed at the G20 Summit held in Hangzhou in 2016. It is an inclusive finance based on digital technology, relying on technologies such as big data analysis and data communication to further eliminate the time and space barriers of financial services, achieve wider population coverage, faster processing procedures and more efficient services. It has a continuous impact on all aspects of financial industry services[5]. Wang Jiang said at the "Building Inclusive Finance and Digital Development" forum that digital construction is becoming a key tool for the development of inclusive finance. He believes that the "contactless" service model is constantly expanding, extending the boundaries of inclusive financial services; the application scope of technology is constantly improving, improving the efficiency of inclusive financial services, and digital technology is conducive to enriching the participants in inclusive finance. And in the long term, the digital inclusive finance model will become an important development trend in the future[6].

Therefore, there is a close relationship between digital development and inclusive finance. The popularization and application of digital technology provides new opportunities and possibilities for the development of inclusive finance. Digital technology can not only reduce the cost and threshold of financial services, making more people able to obtain financial services, but also improve the efficiency and transparency of financial services, reduce information asymmetry and fraud risks; it can also promote financial innovation and provide new products and services for the development of inclusive finance. The following hypothesis is put out in this paper based on the analysis shown above:

Hypothesis 1: There is a mutually reinforcing relationship between digital development and inclusive finance;

Hypothesis 2: Digital development has a positive impact on all aspects of inclusive finance.

2.2. Research methods

2.2.1 Comprehensive index method

The basic principle of the comprehensive index method is to evaluate the importance and performance level of each scheme or object separately and convert the evaluation results into index values [7]. Then, multiply the importance index and performance index to obtain the index of each scheme or object. The higher the index, the higher the importance and performance level of the object, so it is a comprehensive evaluation index. The specific measurement formula is as follows:

$$IFI_i = 1 - \frac{\sqrt{(w_1 - E_1)^2 + (w_2 - E_2)^2 + \dots + (w_k - E_k)^2}}{\sqrt{w_1^2 + w_2^2 + \dots + w_k^2}} \quad (1)$$

IFI_i is the digital development index or inclusive finance index in the i -th region; E_j represents the measurement value of the j -th dimension; w_j represents the weight of the j -th dimension (the combined weight). When IFI_i is 1, it indicates the highest level of development, and when it is 0, it indicates the lowest level. This article evaluates the level of digital development based on three dimensions, while the level of inclusive financial development based on six indicators, and the measurement formula is as follows: $E_j = w_j * x_{ij}$, where x_{ij} represents the standardized value of the j -th indicator in the i -th province; the indicator weight w_i is calculated by a combination of entropy value method and critic method.

2.2.2 Coupling coordination degree model

The coupling coordination degree model is a method used to analyze the interaction and coordination degree between systems. It is usually used to study the relationship between multiple systems. The basic idea of the coupling coordination degree model is to divide the interaction between systems into two aspects: coupling and coordination. Coupling refers to the degree of mutual influence between systems, while coordination refers to the degree of mutual adaptation between systems. The coupling coordination degree model assesses the interaction and coordination degree between systems by calculating the coupling degree and coordination degree between systems. The model calculation formula is as follows:

$$C_{ij} = \sqrt{\frac{S_{ij} * E_{ij}}{(\frac{S_{ij} + E_{ij}}{2})^2}} \quad (2)$$

$$\begin{cases} G_{ij} = \alpha * S_{ij} + \beta * E_{ij} \\ D_{ij} = \sqrt{C_{ij} * G_{ij}} \end{cases} \quad (3)$$

C_{ij} represents the coupling degree, G_{ij} represents the comprehensive coordination index, and D_{ij} is the coupling coordination degree. In this study, it is assumed that both are equally important, so $\alpha = \beta = 0.5$. The coupling coordination degree is between 0 and 1. The larger the value, the stronger the ability of coordinated development between the two; the smaller the value, the weaker the ability of coordinated development between the two[8].

2.2.3 Fixed effects model

The basic idea of the fixed effects model is to decompose panel data into two parts: fixed effects and random errors. Fixed effects are factors that are independent of individuals or time, such as the characteristics of a country or region. Random errors are factors that are related to individuals or time, such as economic cycles or random events. Its advantages are that it can consider the effects of both individuals and time simultaneously, and can effectively control fixed effects. Its mathematical formula is expressed as:

$$y_i = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_p x_{ip} + \varepsilon_i \quad (4)$$

y_i represents the dependent variable of the i -th observation, x_{ij} represents the j -th independent variable of the i -th observation, and β_j represents the coefficient of the j -th independent variable. α represents the intercept term, and ε_i represents the error term of the i -th observation.

3. Empirical analysis

3.1. Data sources and system establishment

This paper takes 31 provinces in China as samples, and the data comes from the official website of the National Bureau of Statistics from 2013 to 2020 and "Peking University Digital Inclusive Finance Index (2011-2020)". According to the research of Di Qianbin[9], Tian Jing[10], and others on digital development(X_1), this article selects three dimensions, which are technology innovation(X_{11}), digital infrastructure(X_{12}), development environment(X_{13}), and 12 small indicators as a comprehensive evaluation index system for digital development; the specific indicators are: R&D full-time equivalent(x_1), R&D funds(x_2), local government science and technology expenditure(x_3), domestic patent applications accepted(x_4), internet broadband access users(x_5), mobile phone users at the end of the year(x_6), the number of computers per hundred people(x_7), the number of websites owned by enterprises(x_8), per capita disposable income of all residents(x_9), number of employees in urban units of information transmission, software and information technology services (x_{10}), employment of urban units in the scientific research and technical service industry(x_{11}), and the number of enterprises with e-commerce transactions(x_{12}). According to the measurement index system of inclusive finance studied by the research group of the Digital Finance Research Center of Peking University, six indicators were selected as the comprehensive evaluation system of inclusive finance(x_2), namely, coverage breadth(X_{13}), usage depth(x_{14}), payment(x_{15}), insurance(x_{16}), credit(x_{17}), and digitalization degree(x_{18}) (Table.1.).

Table.1. Evaluation System of Digital Development and Inclusive Finance

Primary Indicators	Secondary Indicators	Indicators Definition	Nature
X_1	X_{11}	x_1	+
		x_2	+
		x_3	+
		x_4	+
	X_{12}	x_5	+
		x_6	+
		x_7	+
		x_8	+
	X_{13}	x_9	+
		x_{10}	+
		x_{11}	+
		x_{12}	+
X_2	x_{13}		+
	x_{14}		+
	x_{15}		+
	x_{16}		+
	x_{17}		+
	x_{18}		+

3.2. Analysis of the differences in the coupling and coordination degree between two systems

Based on the index system constructed in Table.1., the combined weights of digital development (Table.2.) and inclusive finance (Table.3.) were calculated using the entropy weight method and critic method as follows:

Table.2. Weights of Each Indicator for Digital Development Level

Indicators Year	2013	2015	2017	2019	2020
X ₁	0.0649	0.0863	0.0710	0.0976	0.1033
X ₂	0.0487	0.0897	0.1098	0.1028	0.1103
X ₃	0.0085	0.0214	0.0397	0.0618	0.0363
X ₄	0.0297	0.0247	0.0426	0.0474	0.0671
X ₅	0.0419	0.1097	0.1581	0.1735	0.1759
X ₆	0.1199	0.1157	0.0944	0.0910	0.0734
X ₇	0.1579	0.1615	0.1531	0.1026	0.0967
X ₈	0.3122	0.1308	0.0980	0.0725	0.0690
X ₉	0.0655	0.0865	0.0882	0.0910	0.0842
X ₁₀	0.0597	0.0761	0.0810	0.0880	0.0994
X ₁₁	0.2327	0.0000	0.0000	0.0000	0.0000
X ₁₂	0.0385	0.0975	0.0640	0.0717	0.0841

Table.3. Weights of Each Indicator for Inclusive Finance

Indicators Year	2013	2015	2017	2019	2020
X ₁₃	0.1088	0.1098	0.1322	0.1287	0.0861
X ₁₄	0.1782	0.1259	0.1631	0.1773	0.2480
X ₁₅	0.1038	0.1224	0.3155	0.1367	0.0860
X ₁₆	0.2654	0.1406	0.2003	0.3748	0.4457
X ₁₇	0.2397	0.2847	0.1548	0.1703	0.0727
X ₁₈	0.1041	0.2166	0.0342	0.0798	0.0614

The comprehensive index approach was utilized to determine the measuring outcomes of the two systems, inclusive finance and digital development, based on the combined weights.

The measurement findings show a consistent improvement in the digital level and inclusive finance across all Chinese provinces and cities between 2013 and 2020. The primary causes are that the government has implemented a number of laws to support inclusive finance and digital development, such as the "Implementation Opinions of the State Council on Promoting the High-Quality Development of Inclusive Finance," which guarantee and support the development of inclusive finance and digital development. Financial institutions are concurrently actively promoting digital transformation and innovation. The development of digital level and inclusive finance has also been encouraged, along with the ongoing expansion of consumer demand for financial services, the regular release of financial goods and services that satisfy market demands, and improvements to the accessibility and satisfaction of financial services.

For digital development, on the whole, the digital development level has steadily improved from 2013 to 2020. However, due to the relatively advanced technological level in developed areas such as Zhejiang and Shanghai, the growth rate is not obvious. Relatively backward areas have a higher growth rate in digital development level, such as Jiangxi with a growth rate of 258%, ranking first, and Gansu with a growth rate of 196%, ranking second. In 2020, Guangdong, Jiangsu, and Zhejiang ranked the top three in digital development index, with 0.784, 0.636, and 0.566 respectively; Hainan, Ningxia, Qinghai, and Tibet had the lowest level of digital development, all below 0.1. Overall, China's digitization is steadily advancing, but there are significant differences among provinces.

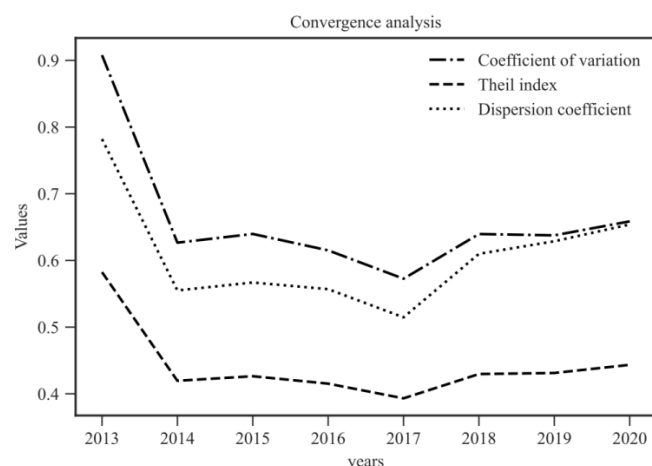


Figure.1. Trends in the Coefficient of Variation, Theil Index, and Coefficient of Dispersion of Digital Development From 2013 to 2020

In terms of the development of inclusive finance, an overall analysis shows that from 2013 to 2020, China's inclusive finance has achieved a leapfrog development. Among them, provinces and municipalities that previously developed slowly, such as Tibet, Qinghai, Gansu, and Guizhou, all saw increases of more than 200%, while the growth rates of other provincial-level administrative regions were also higher than 100%. From a regional perspective, the development of inclusive finance in eastern China is relatively strong, mainly concentrated in coastal provinces and municipalities, especially Shanghai and Zhejiang. In 2020, Shanghai and Zhejiang's inclusive finance indices reached 0.9923 and 0.8955, leading other provinces and municipalities by a large margin. The development of inclusive finance gradually weakened from the central region to the west, especially in Ningxia, Gansu, Qinghai, and Xinjiang. In 2020, the inclusive finance indices of these regions were all below 0.4. The main reasons are that the economic development levels of these regions are relatively low, the income levels of enterprises and individuals are also low, resulting in insufficient financial demand, and the business development of financial institutions is restricted. At the same time, the financial infrastructure in these regions is relatively incomplete, and the efficiency and quality of financial services are relatively low. Finally, by constructing a coupling coordination degree model, the coupling coordination degree between digital development and inclusive finance from 2013 to 2020 was obtained. The measurement of digital development and inclusive finance and the coupling coordination degree between them were also analyzed for heterogeneity.

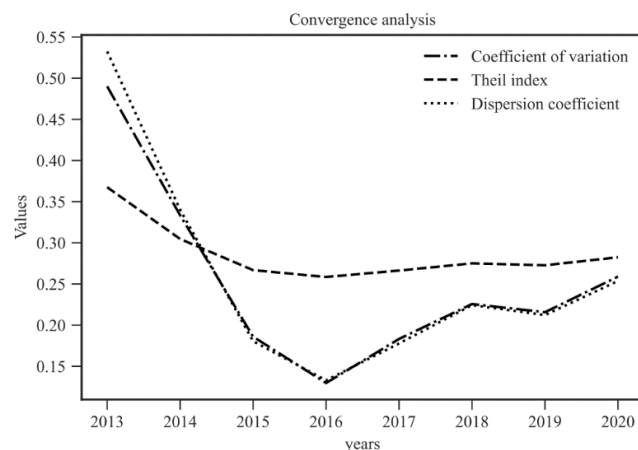


Figure.2. Trends in the Coefficient of Variation, Theil Index, and Coefficient of Dispersion of Inclusive Financial Development From 2013 to 2020

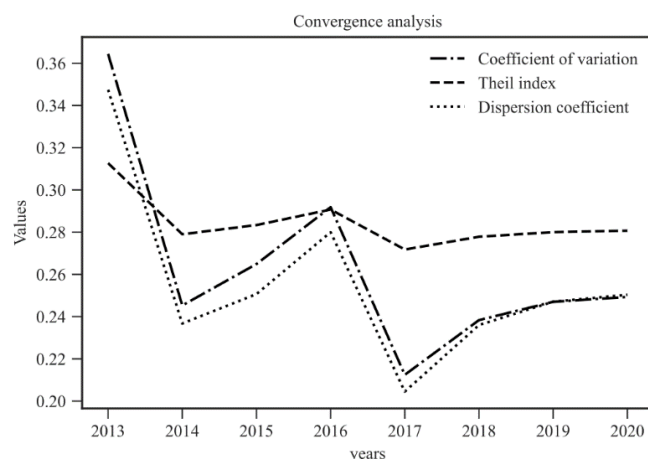


Figure.3. Trends in the Coefficient of Variation, Theil Index, and Coefficient of Dispersion of Inclusive Financial Development From 2013 to 2020

From Figure.1., it can be seen that the coefficients of variation, theil index, and coefficient of dispersion of digital development showed a rapid decreasing trend from 2013 to 2017, fluctuated around a lower value from 2017 to 2020, and both the coefficient of variation and the coefficient of dispersion were above 0.78 in 2013, finally fluctuating around 0.6. From Figure.2., it can be seen that the coefficients of variation and the coefficient of dispersion of inclusive financial development showed a rapid decreasing trend from 2013 to 2016, increased slightly from 2016 to 2020, and finally fluctuated around 0.25, while the theil index showed a slow decreasing trend, finally ranging from 0.25 to 0.3 in 2020. From Figure.3., it can be seen that the coefficients of variation, theil index, and coefficient of dispersion of the coupling coordination degree index were all less than 0.4 each year, showing a trend of first sharp decrease and then increase from 2013 to 2018, and the change was relatively slow from 2018 to 2020. These three figures all show that the gap between regions with initially lower development levels and those with higher levels has gradually narrowed. The reason is that relevant support policies have gradually spread from the initial developed pilot areas to the whole country. The development speed of regions with better foundations has slowed down, while the development of backward areas has accelerated, resulting in a narrowing gap between regions and obvious regional convergence.

3.3. Research on the impact mechanism of digital development level on the development of inclusive finance

To further explore the impact factors of the two, this study employs a fixed effects model to analyze the relationship between the level of digital development and inclusive finance. Firstly, the Hausman test was conducted, and the P-value was less than 0.05, indicating that the fixed effects model should be used. Therefore, a two-way fixed effects model based on clustered robust standard errors was adopted to conduct a regression analysis of digital development and inclusive finance. As shown in Table.4., the coefficients of digital development on inclusive finance and its various indicators are all greater than 0.75, suggesting a significant positive impact of digital development on inclusive finance. Therefore, no control variables were added to this experiment. Overall, digital development plays a promoting role in inclusive finance, highlighting the importance of improving the level of digital development for accelerating the development of inclusive finance.

Table.4. Panel Data Analysis Results of the Relationship Between Digital Development and Inclusive Finance

Dependent Variable Result	R ²	F-Statistic	F-Test Value	Regression Coefficient	Standard error	T-Value	P-Value
X ₂	0.8197	137.16	<0.01	2.2961	0.1961	11.71	<0.05
X ₁₃	0.8800	84.43	<0.01	3.3115	0.3604	9.19	<0.05
X ₁₄	0.8531	142.32	<0.01	2.8221	0.2365	11.93	<0.05
X ₁₅	0.8374	85.21	<0.01	2.8849	0.3125	9.23	<0.05
X ₁₆	0.8370	183.74	<0.01	2.5497	0.1880	13.56	<0.05
X ₁₇	0.8215	82.78	<0.01	2.7202	0.2990	9.10	<0.05
X ₁₈	0.7779	150.79	<0.01	3.2108	0.2615	12.28	<0.05

From Table.4., it can be seen that digital development has a significant impact on inclusive finance and its various indicators. In economic theory, this phenomenon can be well explained by theories of information asymmetry, network externalities, cost-benefit analysis, and competition.

Firstly, the theory of information asymmetry points out that there is an asymmetric distribution of information in the market, which makes some participants at a disadvantage. However, with the development of digital technology, people can exchange information more transparently and effectively, thereby greatly reducing information asymmetry. In this way, not only the fairness of the market is enhanced, but also the efficiency and effectiveness of financial services are improved, thereby promoting the in-depth development of inclusive finance.

Secondly, the theory of network externalities state that if new users enter the network, their benefits will increase with the expansion of the network size. Digital development enhances the externalities of the network by expanding the coverage and influence of financial services, thereby increasing the breadth and depth of inclusive finance. This allows more people to enjoy more convenient and efficient financial services, offering a fresh chance for the advancement of inclusive finance.

Finally, the theory of competition holds that healthy competition in the market can improve the quality and level of products and services. Digital development has increased competition in the financial market, forcing financial service providers to continuously improve the quality and efficiency of their services. This competitive landscape is not only beneficial for consumers to obtain better financial service experiences but also helps promote innovation and development in the financial industry.

In summary, digital development continuously promotes the development of inclusive finance by reducing information asymmetry, enhancing network externalities, lowering costs, and increasing competition. This development not only makes people's lives and production needs more convenient and efficient but also enhances market vitality and promotes the continuous growth of the economy. Therefore, we should fully leverage the advantages of digital economic development to provide better services for inclusive finance.

4. Conclusions and recommendations

Based on the data of 31 provinces in China from 2011 to 2020, this study used various statistical analysis models to find that since 2013, the development level of digitalization and inclusive finance in China has steadily improved. However, there is still a large regional gap, with the eastern and coastal cities developing far better than the western and remote areas. Although the average values of digitization development and inclusive finance indices have been increasing, there is still a significant gap in digitization development levels across different regions, and the overall spatial development pattern of digitization and inclusive finance has not changed. The coefficients of variation, theil index, and discrete coefficient of the two systems have all decreased to some extent, indicating that the development gap between different provinces and cities is continuously narrowing. The coupling and

coordination capacity of digitization development and inclusive finance in China has been continuously increasing, with the overall leap from the near disturbance to barely coordinated stage. The coefficients of variation, theil index, and discrete coefficient of the two systems are all less than 0.4, indicating that the development coordination gap between different provinces and cities has narrowed, and the regional convergence is significant. Finally, digitization development has a significant promoting effect on inclusive finance, and digitization development has a positive impact on all indicators of inclusive finance. Based on the above conclusions, this study proposes the following suggestions:

For regions with higher measurement results in digitization development and inclusive finance development, the government can take various measures to promote the healthy and stable development of the local economy and society, such as promoting economic development, improving people's livelihood, and ensuring financial stability. For example, the government can support technological innovation by establishing innovation funds and providing policy support, support enterprises to conduct technological research and innovation in the digital field and strengthen cooperation and exchanges with underdeveloped areas in the west to promote the common development of digital technology industries. At the same time, the government can encourage cross-sectoral cooperation to promote the deep integration of digital technology and financial services and promote the formation of innovative financial business models to enhance overall economic benefits.

For the digitization development and inclusive finance development in relatively backward areas, the government should focus on solving problems in infrastructure construction, talent training, scientific and technological innovation cooperation, and other aspects to promote the development of the local economy and society. For example, the government should increase investment and accelerate the construction of digital infrastructure, including network coverage, data center construction, to provide a good foundation for digital development.

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