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Research on the Impact of Digital Transformation on the Sustainable Development of Rural Revitalization from the Perspective of SDGs

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ABSTRACT

In 2015, the United Nations introduced the 2030 Agenda for Sustainable Development, which outlines 17 Sustainable Development Goals (SDGs) as a global framework for action. These goals are closely aligned with China's rural revitalization strategy. In the current context, digital transformation has become a crucial enabler in addressing the developmental imbalances between urban and rural areas. However, the deeper relationship between digital transformation and sustainable rural development remains underexplored, with limited systematic research in this area. Existing studies tend to focus on fragmented aspects, failing to capture the broader patterns and regional disparities in China's digital and sustainable rural development. Moreover, the integration of SDGs, digital transformation, and rural sustainable development has not been adequately addressed in the literature, constraining the applicability of prior findings. To fill this gap, this paper employs a time-series dataset from 2017 to 2023 and applies an Ordinary Least Squares (OLS) regression model to conduct an empirical analysis. The results reveal a significant positive effect of rural digital transformation on sustainable rural development. These findings offer both theoretical insights and empirical evidence to support the ongoing advancement of digital rural construction, the refinement of rural revitalization strategies, and the localization of SDG-related efforts in rural areas.

1. Introduction

1.1Research Background

In 2015, member states of the United Nations adopted the 2030 Agenda for Sustainable Development, which includes 17 Sustainable Development Goals (SDGs) and 169 associated targets [1]. However, progress toward these goals has been slow in many countries, and China is actively working to localize the SDGs within its national context. Among these, SDG 1 (No Poverty) and SDG 9 (Industry, Innovation, and Infrastructure) are particularly aligned with the objectives of China's rural revitalization strategy. This strategy serves as the primary approach for addressing challenges related to agriculture, rural areas, and farmers, with core aims including the development of prosperous industries, the creation of livable ecological environments, and the improvement of rural livelihoods [2]. Digital transformation plays a crucial role in this context, acting as a key driver for

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integrating modern information technologies with rural economic development. It has increasingly become a vital force in stimulating rural growth and advancing sustainable development.

In recent years, China has placed strong emphasis on aligning digital rural construction with the SDGs. Policies such as the *Digital Rural Development Strategy Outline* and the *14th Five-Year Plan for Digital Economy Development* have been introduced, accelerating the expansion of digital infrastructure including broadband networks and digital devices in rural areas. This policy push has significantly sped up the digital transformation of rural communities. At the same time, the per capita disposable income of rural residents has continued to rise, indicating ongoing progress in rural sustainable development.

Currently, China's rural digital transformation has seen initial applications in areas such as smart agriculture, e-commerce for rural development, and digital governance. Nonetheless, there remains a lack of systematic research on how to effectively align digital transformation with the SDG framework, particularly in addressing challenges related to ecological conservation, equitable access to public services, and industrial upgrading through technological innovation [3]. Moreover, the digital transition in rural areas continues to face obstacles, including uneven infrastructure development and barriers to the adoption of digital technologies. These issues, along with persistent imbalances in regional development and insufficient ecological protections, pose significant constraints to China's progress toward achieving the SDGs. The specific mechanisms through which digital transformation influences sustainable rural development remain an open area of inquiry.

1.2Research Strategy

This study investigates the impact of digital transformation on rural revitalization through the lens of the Sustainable Development Goals (SDGs). Based on a review of the relevant literature and the collection of empirical data, a quantitative model is constructed. The reliability of the model is subsequently validated through a series of specification tests and robustness checks. The analysis summarizes the effects of rural digital transformation on sustainable development, identifies the limitations of the study, and derives corresponding policy implications and directions for future research. This approach combines theoretical depth with empirical rigor, thereby enhancing the credibility of the findings. By integrating the SDGs, digital transformation, and the sustainable development of rural revitalization into a unified analytical framework for the first time, this paper offers a novel perspective on rural development in China. Focusing on national trends and grounded in the United Nations SDG framework, it examines how digital transformation influences the sustainable outcomes of rural revitalization. In doing so, the study addresses a significant gap in the existing literature and contributes both theoretical insights and practical value to the field of sustainable rural development in China.

2. Literature review

2.1The Impact Of Digital Transformation On Rural Revitalization

In the current context, digital transformation has emerged as a key driver of rural revitalization. Tamara Gajić et al. [4] approached this issue by constructing a smart village index based on data from ten selected rural municipalities with distinct characteristics. Through a multidimensional analysis incorporating indicators such as information and communication technology (ICT) adoption and community engagement, they identified significant regional disparities in the resulting index. Elamurugan Balasundaram et al. [5] examined the role of digital public infrastructure by analyzing Unified Payments Interface (UPI) data from selected villages in India. Their findings suggest that villages with higher UPI adoption tend to experience notable economic growth, and they emphasize the importance of accounting for regional heterogeneity in future research. M. Nasira Banu et al. [6]

focused on rural areas in Kerala, highlighting the critical role of digital financial literacy particularly in rural and marginalized communities in promoting equitable development. Liao Minling et al. [7] centered their analysis on short video and live streaming platforms, employing an analytical framework based on industrial, human, cultural, ecological, and organizational revitalization. Their study systematically explores the pathways through which these platforms empower rural revitalization, providing a representative case for understanding the concrete applications of digital transformation in rural settings. Liu Jing [8] adopts the perspective of the livestock sector to investigate the practical foundations, core objectives, and optimization pathways of digital transformation within the broader rural revitalization strategy. The study not only examines the application of technologies such as the Internet of Things and big data across various stages of livestock production but also links these developments to the overarching goals of agricultural modernization and rural industrial upgrading. It thus offers valuable insights into the implementation of digital transformation in the agricultural sector.

2.2Research On Rural Sustainable Development

Sustainable rural development is a multidimensional concept that encompasses economic, ecological, social, and governance dimensions. At its core, it seeks to meet the basic needs and developmental aspirations of current rural populations while ensuring the long-term capacity to provide ecological goods and public services for future generations, all within the carrying capacity of rural ecosystems [9]. Meng Zhigang et al. [10] argue that, within the context of rural revitalization, sustainable rural development should be pursued through three interrelated mechanisms: factor upgrading, technology-enabled empowerment, and policy coordination. Their framework elucidates the transition from traditional agriculture toward a more modern, environmentally sustainable, and intelligent mode of production. By integrating both macro-level policy analysis and micro-level case studies, their research offers a systematic lens through which to examine sustainability transitions in the agricultural sector. Hu Xiao et al. [11] investigate the potential for leapfrog development in remote rural areas by constructing an integrated framework that combines digital empowerment with cultural drivers. Using the village of Zhagana in Gansu Province as a case study, they explore how synergies between digital technologies and rural cultural resources can underpin sustainable development. Their approach moves beyond conventional unidimensional explanations, emphasizing instead the organic integration of technological and cultural factors. Liang Zhihua [12] draws on the Third National Conference on Forestry Industry to examine the multifunctional attributes of the forestry sector, particularly its contributions to ecological conservation, industrial upgrading, and income generation for rural households. The study identifies practical challenges to the sustainable development of forestry and proposes pathways for optimization. By framing the forestry sector as a vital engine for rural revitalization, this research contributes a sector-specific perspective to the broader discourse on diversifying rural economies. Yuan Tongkai et al. [13] focus on the sustainability of rural tourism, proposing a relational turn in research approaches. They develop a tripartite analytical framework that integrates conceptualization, indicator systems, and practical application. Departing from conventional unidirectional perspectives, their framework conceptualizes rural tourism as a complex system characterized by multi-actor and multidimensional interactions. In doing so, it provides a theoretical foundation for understanding the synergistic relationship between tourism development and broader rural development objectives.

2.3. Research on SDGs and Rural Revitalization

Since the adoption of the United Nations Sustainable Development Goals (SDGs), countries worldwide have been engaged in efforts to localize the global framework within their respective

national contexts. In the case of China, progress on the economic dimensions of the SDGs has been relatively robust. However, notable imbalances persist across different regions [14]. The localization process has also contributed, to some extent, to the advancement of China's rural revitalization strategy. For instance, Jia Mingming et al., drawing on an analysis of mangrove ecosystems in China over the past five decades, find that substantial areas of mangroves have been placed under effective protection between the baseline year of the SDGs and 2020 [15], thereby playing a significant role in sustaining rural ecological systems. Xu Yuting et al., in their examination of climate-smart agriculture within the SDG framework, identify a close linkage between such agricultural practices and multiple SDG targets, suggesting that climate-smart agriculture can facilitate progress toward the realization of relevant goals [16]. Similarly, climate governance is deeply intertwined with the SDGs, and a deeper integration of climate action with the broader SDG agenda may contribute to inclusive development and shared prosperity on a global scale [17].

Despite these advances, progress toward the SDGs has been uneven and, in many respects, slower than anticipated. Countries continue to face substantial challenges, including gaps in data availability, limited monitoring capacity, the inherent complexity of interlinkages among different SDGs, regional disparities, and negative spillover effects. In addition, insufficient integration of scientific research, policy design, and social engagement, compounded by the uncertainties introduced by global environmental change, further impedes the achievement of the goals [18]. In light of these challenges, scholars have emphasized the need for greater attention to issues of global inequality and uneven development [19].

Parallel to the pursuit of the SDGs, progress in green development in rural areas has also advanced steadily, contributing positively to the broader objectives of rural revitalization [20]. Rural revitalization is, in essence, oriented toward the goal of sustainability, and sustainable development constitutes a core requirement of the revitalization process. The two are mutually reinforcing, achieving synergistic advancement through mechanisms such as harmonizing human–land relations, fostering rural industries, and strengthening social capital [21].

2.4. Literature Review

Existing research on the relationship between digital transformation and sustainable rural development has largely been conducted at a regional or local level. These studies have generally confirmed the positive effects of digital transformation on rural sustainability and have contributed to the development of preliminary theoretical frameworks and analytical methods. However, this body of literature has notable limitations. First, its findings lack empirical validation at the national level, leaving the generalizability of the conclusions uncertain. Second, most studies have focused on theoretical construction, with relatively few providing rigorous quantitative empirical evidence. Furthermore, existing research tends to examine the link between digital transformation and sustainable rural development in isolation, without integrating the Sustainable Development Goals (SDGs) as a core analytical dimension.

To address these gaps, this study adopts the SDGs as its central analytical lens and investigates the impact of digital transformation on sustainable rural development using nationally representative data. By integrating the three previously disconnected strands of research SDGs, digital transformation, and rural sustainability this paper not only builds upon the foundational insights of prior work but also introduces theoretical and methodological innovations. In doing so, it aims to provide a more comprehensive and empirically grounded understanding of how digital transformation can contribute to sustainable rural development within the framework of the SDGs.

3. Research Design

3.1 Empirical Model

Based on the above literature review and the localization practice of SDGs in China, this paper uses relevant data from 2017 to 2023 and employs OLS to construct a linear regression model. This paper establishes the following model：

$$Y_t=\alpha_0 + \alpha_1 X_t + \alpha_2 C1_t + \varepsilon_t \quad (1)$$

In the equation, Y_t is the dependent variable, representing the per capita disposable income of rural residents nationwide, which is used to measure the level of rural sustainable development and corresponds to SDG 1. X_t is the core explanatory variable, representing the number of rural broadband subscribers, which is used to measure the level of rural digital transformation and corresponds to SDG 9. $C1_t$ is the control variable, representing the national fiscal expenditure for agriculture, forestry, and water conservancy, which measures the intensity of policy support. α_0 is the intercept term, and α_1, α_2 are the correlation coefficients of the variables. ε_t is the random error term.

3.2Explanation Of Variable Selection and Data Sources

This study selects the per capita disposable income of rural residents as the primary dependent variable, which corresponds to SDG 1 (No Poverty) and serves as a core indicator of rural prosperity. To measure the extent of rural digitalization, the number of households with broadband access is employed as the key explanatory variable. This metric directly reflects the state of digital infrastructure, aligning closely with SDG 9 (Industry, Innovation, and Infrastructure), which identifies infrastructure as a fundamental carrier of digital transformation. Government expenditure on agriculture, forestry, and water conservancy is included as a control variable, given that public fiscal investment plays a crucial role in supporting rural development by directly influencing agricultural productivity and infrastructure construction.

The data utilized in this study are drawn from multiple official sources. Data for the dependent variable are obtained from the National Bureau of Statistics of China. The core explanatory variable, along with data on the number of mobile phone owners per 100 rural households, is sourced from the China Statistical Yearbook. Information on national fiscal expenditure on agriculture, forestry, and water conservancy is retrieved from the Central Government Budget Public Platform. The combination of these datasets ensures both the reliability and the national representativeness of the empirical analysis.

3.3. Descriptive Statistics

Descriptive statistics of the relevant variables are shown in Table 1

Table 1
OLS Regression Results(1)

Variable	Obs	mean	Std.dev.	Min	Max
Y	7	17422.29	2991.281	13432	21691
X	7	14482.56	3376.482	9377.3	19189.2
control1	7	22455.7	2296.319	19280.2	24975.47

3.4. Model Testing

3.4.1. OLS regression

The regression results are shown in Tables 2, 3, and 4. As presented in Tables 2 through 4, the coefficient for rural broadband access users is 0.8308706. This indicates that for every additional 10,000 households with broadband access, the per capita disposable income of rural residents

increases by 0.8308706 RMB. The associated p-value is 0.001, which falls below the conventional significance level of 0.05, suggesting that the number of rural broadband access households has a statistically significant positive effect on rural per capita disposable income. In contrast, the coefficient for national fiscal expenditure on agriculture, forestry, and water conservancy is 0.0845279, implying that a one-billion-RMB increase in such expenditure corresponds to a 0.0845279 RMB rise in rural per capita disposable income. However, the p-value for this variable is 0.583, exceeding the 0.05 threshold, indicating that its effect is not statistically significant. The R-squared value of 0.9857 suggests that the model exhibits a strong goodness of fit. The following section presents a series of diagnostic tests to further assess the robustness and validity of the model.

Table 2
OLS Regression Results(2)

Source	SS	df	MS
Model	52918480.6	2	26459240.3
Residual	768088.795	4	192022.199
Total	53686569.4	6	8947761.57

Table 3
OLS Regression Results(3)

Y	Coefficient	Std. err.	t	P>|t|	[95% conf. interval]	
X	0.8308706	0.0968571	8.58	0.001	0.5619523	1.099789
contorl1	0.0845279	0.1424176	0.59	0.583	-0.3108866	0.4799425
_cons	3491.02	2170.738	1.61	0.183	-2535.914	9517.955

Table 4
OLS Regression Results(4)

Number of obs	F(2, 4)	Prob > F	R-squared	Adj R-squared	Root MSE
7	137.79	0.0002	0.9857	0.9785	438.2

3.4.2Test for homoscedasticity

As reported in Table 5, the test yields a p-value of 0.2522, which exceeds the conventional significance threshold of 0.05. Accordingly, the null hypothesis of constant variance cannot be rejected, indicating that heteroskedasticity is not present in the model.

Table 5
Homoscedasticity test result

Chi2(1)	Prob>chi2
1.31	0.2522

3.4.3Multicollinearity Test

To assess potential multicollinearity among the explanatory variables, a variance inflation factor (VIF) test was conducted. As reported in Table 6, all VIF values are below the conventional threshold of 5, indicating that multicollinearity does not pose a concern in the regression analysis.

Table 6
Multicollinearity test result

Variable	VIF	1/VIF
control1	3.34	0.299232
X	3.34	0.299232
Mean VIF	3.34	

3.4.4Test for normality of residuals.

To evaluate whether the residuals conform to a normal distribution, a normality test was performed. The results, presented in Table 7, yield a p-value of 0.96. Given that this value substantially exceeds the 0.05 significance level, the null hypothesis of normality cannot be rejected. This suggests that the residuals are approximately normally distributed.

Table 7
Residual Normality Test Results

Variable	Obs	W	V	Z	Prob>z
resid	7	0.98153	0.243	-1.833	0.96

3.4.5. Model Fit Test

To evaluate the adequacy of the model specification, a goodness-of-fit test was conducted. As shown in Table 8, the resulting p-value is 0.2249, which exceeds the 0.05 significance level. Therefore, the null hypothesis cannot be rejected, indicating that the model is appropriately specified and exhibits a satisfactory fit.

Table 8
Model Fit Test Results

F(3,1)	Prob>F
10.24	0.2249

3.5. Robustness Test

To assess the robustness of the regression results, a robustness check is conducted using a variable substitution approach. Specifically, the core explanatory variable is replaced with an alternative indicator: the average number of mobile phones owned per 100 rural households (denoted as X1). The dependent variable and control variables remain unchanged, and the regression model is estimated using the same specification as in the baseline analysis.

Y_t=$\alpha_0 + \alpha_1 X1_t + \alpha_2 C1_t + \varepsilon_t$ (2)

The regression results from the robustness check indicate that replacing the core explanatory variable does not alter the relationship between the dependent and independent variables. The overall explanatory power of the model remains intact, and the coefficients for the control variables are consistent with those obtained in the baseline regression. These findings suggest that the original model is robust and that the main conclusions are reliable.

Table 9
Robustness Test Results(1)

Source	SS	df	MS
Model	47738701.3	2	23869350.7
Residual	5947868.11	4	1486967.03
Total	53686569.4	6	8947761.57

table 10
Robustness Test Results(2)

Y	Coefficient	Std. err.	t	P>|t|	[95% conf. interval]	
X1	275.9483	112.4737	2.45	0.07	-36.32877	588.2254
control1	0.2724759	0.4034381	0.68	0.536	-0.8476479	1.3926
_cons	-60833.19	22304.53	-2.73	0.053	-122760.5	1094.113

table 11
Robustness Test Results(3)

Number of obs	F(2, 4)	Prob > F	R-squared	Adj R-squared	Root MSE
7	16.05	0.0123	0.8892	0.8338	1219.4

4. Conclusion And Discussion

4.1. Conclusion

This study employs time-series data spanning from 2017 to 2023 and applies an Ordinary Least Squares (OLS) regression framework to examine the relationship between rural broadband access and the per capita disposable income of rural residents. Through a series of diagnostic tests, the analysis explores the linkage between the level of rural digital transformation and sustainable development outcomes. The empirical results indicate that rural digital transformation exerts a statistically significant positive effect on sustainable rural development. More specifically, an increase in the degree of digitalization is associated with improvements in rural sustainability. In addition, national fiscal expenditure on agriculture, forestry, and water conservancy is incorporated as a control variable to capture the role of infrastructure investment. The findings suggest that greater infrastructure spending is positively correlated with enhanced rural sustainable development. This study contributes to the literature by addressing the previously underexplored intersection of the SDGs, digital transformation, and sustainable rural development within a unified analytical framework. It offers empirical evidence to support China’s ongoing efforts in digital rural construction and the implementation of its rural revitalization strategy, while also providing practical insights for the localization of the SDGs.

4.2Limitations

Despite its contributions, this study has several limitations. First, the selection of variables is relatively narrow. The level of rural digital transformation is measured solely by the number of rural households with broadband access, without incorporating alternative or complementary indicators. Similarly, rural sustainable development is captured only through its economic dimension, while ecological, social, and other relevant aspects are not accounted for. As a result, the variables may not fully reflect the multidimensional nature of the concepts under investigation. Second, the time span of the data is limited to a seven-year period (2017–2023), which constrains the ability to capture the long-term dynamic effects of digital transformation on sustainable rural development. This short timeframe also makes it difficult to identify evolving trends in the long-run relationship between the variables. Third, the study does not account for regional heterogeneity. Given the substantial disparities in economic foundations and digital infrastructure across China’s eastern, central, and western regions, the impact of digital transformation on sustainable rural development may vary geographically. The absence of region-specific analysis thus limits the applicability and precision of the conclusions.

4.3Future Prospects

Future research could consider incorporating a broader range of indicators to more comprehensively measure both the level of rural digital transformation and the multidimensional nature of sustainable rural development. Constructing a more detailed evaluation index system would allow for a fuller representation of these concepts. In addition, extending the time span of the data would increase the sample size and enhance the precision and generalizability of the empirical findings. Furthermore, it would be advisable to conduct regional heterogeneity analysis to examine

how the relationship between digital transformation and sustainable rural development may differ across China's eastern, central, and western regions. Such analysis would provide a more nuanced understanding and support the formulation of region-specific policy recommendations tailored to local conditions.

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Data Availability Statement

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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