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Research Article

Impact of Digital Economy on Living Standards and Equality in Rural and Urban Areas of China

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ABSTRACT

Digital economy is one the most crucial phenomena of the 21st century affecting social and economic development indicators such as income levels and equality. This study aims to investigate how digital economy impacts urban-rural income levels and equality in China. This study employs a fixed effects model to estimate this relationship from 2011 to 2020 in the whole urban and rural areas as well as in the western, central, and eastern regions of China. The results show a positive relationship between the digital economy and living standards in urban and rural regions. In addition, the results reveal that the digital economy narrows the rural-urban gap since this effect is more considerable in rural areas than the urban ones. More specifically, the findings indicate that the digital economy improves equality among various rural areas, due to its higher impact on the western rural area which is the least-developed region in China. Therefore, digitalization improves both social and economic development indicators like living standards

and equality. The findings of this research suggest policymakers develop digital structures, especially in rural and less-developed areas particularly the western region, to not only improve equality in these specific areas but also increase economic activities throughout the region.

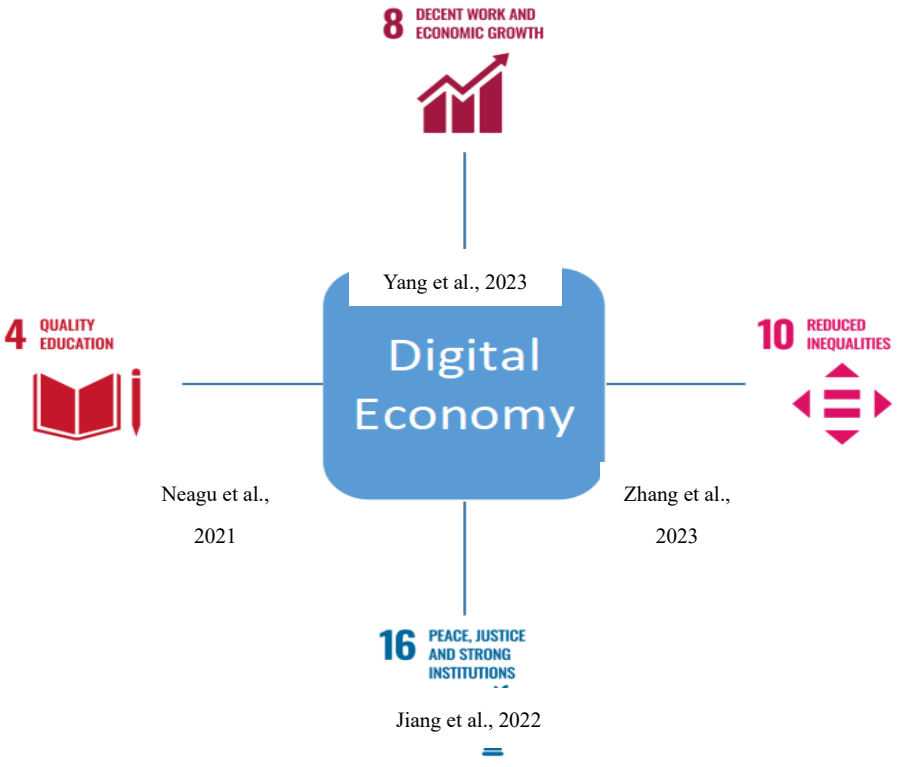
Keywords: : Digital economy,equality, urban-rural gap, living standard, sustainable development goals

JEL Classification: D31,J19,R13,

INTRODUCTION

Digital economy has an important relationship with different aspects of social, environment, and economy, as well as the sustainable development goals (SDGs) (Chen et al., 2023; Nasrollahi et al., 2020; Nodehi et al., 2022; Redshaw 2020; Rosário and Dias 2023; Soretz et al., 2023). Figure 1 shows how digital economy affects four SDGs including SDGs 4, 8, 10, and 16. For example, digital economy directly reforms the economic opportunities and structure among different people affecting the income level, or rather SDG 8 (Decent work and economic growth). This effect occurs in various economic regions, directly impacting the distribution of income which is consistent with SDG 10 (reduced inequalities) and SDG 16 (Peace, justice and strong institutions). In addition, the digital economy can indirectly affect income equality via social factors (Chen and Zhang, 2023). For example, it plays a crucial role in distributing knowledge, education, and information among different people in various regions, providing new opportunities for income growth and affecting income equality (Chen and Zhang, 2023; Youxue and Shimei, 2022). Therefore, a study on the impact of digital economy on various aspects of human life like income level and equality is important particularly with regards to the mechanism, direction, and its magnitude.

Figure 1- Impact of digital economy on sustainable development goals (SDGs) of the United Nations (UN)



The digital economy can increase living standards and equality between rural and urban residents via many

channels including access to markets, remote work opportunities, skill development and education, financial inclusion, and agricultural efficiency (Jiang et al., 2022; Zhang et al., 2023). For example, digital economy and e-commerce can help rural businesses to access larger markets beyond their local alternatives, giving not only higher income but also more equal market opportunities to rural residents (Cheng and Zheng, 2023; Tiwasing et al., 2022). A villager can also work remotely for a knowledge-based industry such as online tutoring, customer support, designing, and programming. Moreover, the digital economy offers various financial services (e.g., online banking and payment platforms) facilitating the financial flows, benefiting the rural entrepreneurs and enterprises in the transaction of their income from their online work in their village far from the main banks in the urban areas. In this way, the digital economy increases the income of knowledgeable and expert rural communities to decrease their income gap with their urban counterpart (Chetty, 2018; Deng et al., 2023; Hao and Ji, 2023).

In addition to knowledge community, the digital economy helps people with lower levels of skills in rural areas to improve their employability and income capacity using online education and skill development training (Neagu et al., 2021; Shaibu, 2018; Shirazi et al., 2020; Zhang et al., 2023). With higher competencies and education levels, the digital economy can increase the rural communities' chances to compete with their urban counterpart for employment (Lu et al., 2022; Wang et al., 2023). If these villagers and farmers intend to improve their traditional work and agricultural practices, the digital economy provides opportunities to increase their income and decrease their gap with urban people; they can apply digital agricultural tools, precision farming, smart irrigation, crop monitoring, disease detection, farm management software, agricultural knowledge sharing online-platforms, and weather forecast apps. Therefore, the digital economy can increase the income level in rural areas even among those with a lower level of knowledge or have agriculture as the main occupation, which reduces their income gap with urban people (Liu, 2017; Li et al., 2022; Yin et al., 2022)

However, the digital economy can reduce income levels and increase the gap between rural and urban communities through the digital divide, skill gaps, concentration of tech hubs, and cybersecurity risks (Liu et al., 2023; Liu and Zhou, 2023; Qin, 2022). The digital divide is a critical factor in widening the gap between urban and rural livelihoods via unequal distribution of the Internet and digital technologies (Laskar, 2023). Tech hubs have agglomerated digital economic activities in larger urban areas, accelerating the unequal distribution of digital opportunities. In addition, more resources and experts gather in urban areas, leaving rural digital services with more risk of cybercrime, increasing the unequal distribution of digital services (Bernik, 2022; Khan, 2023). If this distribution is unequal, the digital economy would be an additional factor in broadening the inequality of urban and rural people not only from the perspective of labor supply, but also regarding the training and education development activities for improving personal and employment skills.

In addition to the factors rooted in the unequal distribution of digital facilities, the digital economy directly decreases income levels and increases the gap between rural and urban areas like job displacement and market dominance (Qiu, 2023; Xu, 2022). For example, it causes job displacement which decreases the income level among rural communities. In other words, digitalization and automation remove the traditional rural industries, leading to unemployment and wage reduction for the affected ones (Yang et al., 2023). Moreover, large companies can dominate or have already dominated digital markets, restricting rural communities to competition and decreasing their income opportunities. Therefore, the digital economy can reduce living standards and increase the gap between rural and urban people (Nijman and Wei, 2020).

These two conflicting viewpoints regarding the effects of the digital economy on the living standards and equality of urban and rural people require a deep investigation, especially with regards to China. China has shown one of the greatest rates of economic growth in the world while emphasizing socialist benefits and equality. For these reasons, China is a unique case for investigating these conflicting viewpoints with regard to the effects of the digital economy

on equality. These different outlooks propose the questions of how the digital economy affects income equality of rural and urban people, whether the digital economy reduces the income gap between the two groups, and through which mechanism the digital economy exerts its effects on income equality.

This research aims to investigate whether the digital economy has a positive effect on living standards and equality in China. Innovatively, this study considers this effect not only within various rural areas but also between rural and urban communities as a social equality indicator to measure the impact of the digital economy on equality. In this way, this research will provide some theoretical and political contributions. This study theoretically contributes to the literature on how the digital economy affects living standards and equality, specifically from the perspective of rural and urban income levels. The findings of this research can shed light on the nexus of the digital economy and income equality to practically help policy-makers adopt strategies to promote both economic and social development via increasing living standards and equality by fostering an equitable and comprehensive sustainable development.

LITERATURE REVIEW

Numerous researchers have examined the relationship of digital economy and equality but they have reached different conclusions. Table 1 represents these studies, time and group samples, as well as findings.

According to Table 1, some studies show a positive relationship between the digital economy and economic prosperity. For example, Zhang et al., (2011) measured the digital economic development index of 30 cities in China during 2015 and 2019 according to three aspects of digital infrastructure, industry, and integration, and showed a positive relationship between the digital economy and income level. In addition, Leng, (2022) used a survey of rich families in China during 2010 and 2018 and found out that the digital revolution has a positive impact on rural households' income. Pang et al. (2022) confirmed this positive relationship regarding high-quality economic development in China. Zhang et al., (2022) revealed that the digital economy positively affected the wage rate and negatively impacted the gender wage gap in China in 2018. Moreover, Jiang and Jin (2023) showed that the digital economy narrowed the urban and rural income gap in China. Similarly, Li and Jiang (2023) indicated a positive relationship between the digital rural index and the income of farmers' community in the Jilin province of China.

From a global perspective, the aforementioned results were confirmed based on a systematic review by Oloyede et al., in 2023 concerning developing countries showed a positive relationship between the digital economy and income. Specifically, they suggest that Nigeria needs to promote digitalization so as to improve its economy. In addition, Wang et al. in 2023 investigated a sample of 81 developing countries between 2002 and 2019 and reached a similar conclusion about the positive effect of the digital economy on income, equality, and public health in 81 developing countries. Another study that confirmed this positive relationship in terms of the digital economy and common prosperity in China during 2011 and 2019 is that of Zhao et al., in 2023.

However, some studies have indicated a negative effect of the digital economy on income level and equality. For example, Sorgner in 2017 investigated German households and showed a negative relationship between automation of jobs and labor prosperity. Then, Bessen in 2019 investigated data of about two centuries and suggested a negative connection between technology advancement and job growth in the following three US industries: textile, steel, and auto. After that, Guellec 2020 showed a negative relationship between digital innovation and income equality in OECD countries. In addition, Jetha et al., 2023 interviewed 40 experts in Canada and showed that digitalization reduces equality. Similarly, Yang et al., in 2023 investigated Chinese households during 2010 and 2020 and showed a positive relationship between the digital economy and the wage distribution gap between high- and low-skilled workers.

These two conflicting conclusions regarding the relationship between the digital economy and living standards

propose a research gap about how digitalization affects the economic and social prosperity of households. This paper tries to bridge this gap by estimating this connection in rural and urban areas of China.

Table 1. A summary of previous studies on the nexus of digital economy and economic and social prosperity

Study	Period	Sample	Factor	Relation
Zhang et al., (2021)	2015 to 2019	30 cities in China	High-quality economic development and three dimensions of digital infrastructure, industry, and integration	+
Leng, (2022)	2010 to 2018	Rich family survey data from the China Family Panel Studies	Rural households' income	+
Pang et al. (2022)		China	High-quality economic development	+
Zhang et al., (2022)	2018	China	Gender wage rate	+
Jiang and Jin, (2023)	2017	China	Digital economy and urban-rural income gap	+
Li and Jiang, (2023)	2018–2020	Jilin Province of China	Digital rural index and farmers' household income	+
Oloyede et al., (2023)	Systematic review	Developing countries	Income	+
Wang et al., (2023)	2002 to 2019	81 developing countries	Income, income equality, and public health	+
Zhao et al., (2023)	2011 to 2019	China	Common prosperity	+
Sorgner, (2017)		German households	Automation of jobs and occupational mobility	-
Bessen, (2019)	Two centuries	Three US industries: textile, steel, and auto	Technology advancement and job growth	-
Guellec, (2020)		OECD countries	Digital innovation and income equality	-

Jetha et al., (2023)		Forty Canadian experts	Income equity	-
Yang et al., (2023)	2010–2020	China Family Panel Studies (CFPS) database	Wage gap between high- and low-skilled workers	-

METHODOLOGY

2.1.Model specification and variables

This research estimates the relationship of the digital economy with the rural residents' living standards within 310 different villages of 31 provinces in China from 2011 to 2020. This estimation uses the following function assuming that living standards are a function of digitalization and some control variables.

$$LS = f(D, Xs) \quad (1)$$

where LS is living standard, D is digitalization, and Xs are control variables. For estimating this function, this research transforms it into the following econometric models with some proxies for the variables.

$$EC_{i,t} = C + \alpha_1 DE_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$EC_{i,t} = C + \alpha_1 DE_{i,t} + \alpha_2 Op_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$EC_{i,t} = C + \alpha_1 DE_{i,t} + \alpha_2 Op_{i,t} + \alpha_3 St_{i,t} + \varepsilon_{i,t} \quad (4)$$

$$EC_{i,t} = C + \alpha_1 DE_{i,t} + \alpha_2 Op_{i,t} + \alpha_3 St_{i,t} + \alpha_4 Y_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$EC_{i,t} = C + \alpha_1 DE_{i,t} + \alpha_2 Op_{i,t} + \alpha_3 St_{i,t} + \alpha_4 Y_{i,t} + \alpha_5 Ed_{i,t} + \varepsilon_{i,t} \quad (6)$$

$$EC_{i,t} = C + \alpha_1 DE_{i,t} + \alpha_2 Op_{i,t} + \alpha_3 St_{i,t} + \alpha_4 Y_{i,t} + \alpha_5 Ed_{i,t} + \alpha_6 Tr_{i,t} + \varepsilon_{i,t} \quad (7)$$

where EC is Engel coefficient, DE shows digital economy index, Op is openness, St represents industrial structure, Y signifies gross domestic product (GDP), Ed indicates education input level, Tr is traffic density, C denotes intercept, αs are the coefficients of the variables, ε indicates error term, i is region, t presents year, and j shows control variable number. In this regression, α_2 shows how the digital economy affects the living standards of rural residents. If α_2 has a positive sign, the digital economy improves the rural residents' living standards; but if it is negative, the digital economy lowers the rural residents' living standards.

Following Leng, (2022), Pang et al., (2022), and Zhang et al., (2021), the control variables are industrial structure, openness, gross domestic product, education input level, and traffic density. Table 2 represents the definition and description of the variables. According to Table 2, this research follows Chenhao, (2015) to consider the Engel coefficient as a proxy for rural residents' living standards derived from the National Bureau of Statistics. The smaller the value, the higher the living standard. Following Tao et al., (2020), the digital economy is the comprehensive development index of the digital economy measured by the entropy method as a combination of two levels of indexes (see Table A-1 in the appendix).

Table 2. Variable definition

Variable	Name	Symbol	Definition
Explained	Living standards of rural residents	EC	Engel coefficient value
Explanatory	Digital economy level	DE	Digital economy development index constructed by Tao et al. (2020)
Control	Level of basic transportation facilities	Tr	Density of traffic network
	Industrial structure	St	Proportion of value-added of tertiary industry in GDP
	Degree of opening-up	Op	Total imports and exports of goods Proportion of USD/RMB exchange rate in GDP
	Economic development level	Y	Gross domestic product (GDP) at regional level
	Educational investment level	Ed	Proportion of provincial expenditure on education in the general public budget

The data comes from the National Bureau of Statistics, Statistical Yearbook, Statistical Yearbook of the Tertiary Industry, Yearbook of Information Industry, Peking University Digital Financial Inclusion Index, National Bureau of Statistics, and Provincial Statistical Yearbook.

2.2.Comparative analysis

Furthermore, this research adds a comparative analysis by estimating the relationship of the digital economy index with living standards not only within the three eastern, central, and western rural areas, but also between the total rural and urban areas, separately. For this comparison, this research estimates Equations 1 to 6 for the western, central, and eastern rural areas as well as the total urban areas. If the results are different in these areas, the digital economy affects inequality in China. Given the constructive role of the digital economy in living standards, this effect narrows the inequality if the resulting effect of the digital economy index is more beneficial in less-developed areas (rural areas, especially the western one).

2.3. Mechanism of the effect

This research goes beyond finding the nexus of the digital economy and living standards by investigating the mechanism through which the digital economy affects living standards in rural areas of China. This exploration follows Zhonglin et al., (2004) to use the following classic three-step test method.

$$Ex_{i,t} = C + \beta_1 DE_{i,t} + \beta_2 Op_{i,t} + \beta_3 St_{i,t} + \beta_4 Y_{i,t} + \beta_5 Ed_{i,t} + \beta_6 Tr_{i,t} + \varepsilon_{i,t} \quad (8)$$

$$EC_{i,t} = C + \theta_1 Ex_{i,t} + \theta_2 DE_{i,t} + \theta_3 Op_{i,t} + \theta_4 St_{i,t} + \theta_5 Y_{i,t} + \theta_6 Ed_{i,t} + \theta_7 Tr_{i,t} + \varepsilon_{i,t} \quad (9)$$

where Ex is household consumption expenditure, and βs and θs are coefficients of the variables. If the results of Equations 1 to 6 confirm the effect of the digital economy on living standards, then, Equations 7 and 8 can check whether this effect flows through household consumption expenditure. If β_1, θ_1, and θ_2 are statistically significant, the household consumption expenditure has an intermediatory role in the effect of the digital economy on living standards.

2.4. Robustness and preliminary tests

Before estimating the models, the Hausman test examines whether the regression follows fixed or random effects, where the null hypothesis infers random effects. After estimating the models, robustness tests examine the validity and reliability of the results and conclusions. These test alternates the control variables, sample size, and estimation method to check whether the results are stable even after manipulating the variables, samples, and estimation method. Firstly, the robustness tests add human capital as a new control variable which measures the talent level based on the proportion of the number of college students in each region in the total population of the region. Then, they reduce the sample size, considering the particularity of the four municipalities in urban and rural construction, government policies, resource endowments, and other regional development. Finally, the regressions change the estimation method and re-estimate the models using Ordinary Least Squares (OLS). If the results of the robustness tests are consistent with those of Equations 1 to 6, the conclusions are stable, valid, and reliable.

RESULT

3.1. Preliminary analysis

Table 3 represents various descriptive statistics of the research variables. According to Table 3, the mean value of the explained variable, the living standard of Chinese rural residents, is 34.24, and its minimum and maximum values are 23.80 and 54.25, respectively. These values indicate a low overall living standard of rural residents is low with a wide gap and substantial inequality. In addition, the average degree of the digital economy is 0.371, whose minimum and maximum values are 0.0773 and 0.982, respectively. According to these values, different regions have experienced various degrees of digital economy, implying a huge gap.

Table 3. Descriptive statistics

Variable	Average	SD	Minimum	Maximum
EC	34.24	6.20	23.80	54.25
Y	23.65	20.89	611.5	110.76
Ed	16.22	2.70	9.89	22.22
Tr	0.94	0.53	0.05	2.23
Ex	1.65	0.71	0.50	4.56
DE	0.37	0.17	0.07	0.98
Op	0.26	0.29	0.00	1.54
St	47.32	9.65	29.67	83.87

Note: SD is standard deviation.

3.2.Baseline model results

The results show a positive relationship between the digital economy and the residents' living standards in rural and urban areas of China. Table 4 represents the results of the fixed model according to the result of the Hausman test which rejects the null hypothesis or random effects model. According to Table 4, the estimations of all the models show that all the coefficients of the digital economy index are negative and statistically significant at 1% level. This result indicates a negative relationship between the digital economy index and the Engel coefficient, implying the positive nexus of the digital economy and living standards in both rural and urban areas.

Table 4. Results of estimating the nexus of the digital economy index and Engel coefficient in rural areas of China

	1	2	3	4	5	6
DE	-17.838***	-17.126***	-12.168***	-10.595***	-10.689***	-9.272***
	(-17.00)	(-14.78)	(-5.70)	(-4.52)	(-4.55)	(-3.73)
Op		3.278	4.359*	3.343	3.158	3.433
		(1.43)	(1.90)	(1.41)	(1.32)	(1.44)
St			-0.166***	-0.161***	-0.146**	-0.133**
			(-2.75)	(-2.67)	(-2.30)	(-2.08)
Y				-0.000	-0.000	-0.000
				(-1.61)	(-1.60)	(-1.58)
Ed					0.119	0.136
					(0.70)	(0.80)
Tr						-4.464*
						(-1.71)
C	40.864***	39.743***	45.457***	46.248***	43.729***	46.396***
	(96.31)	(44.73)	(20.16)	(20.09)	(10.24)	(10.24)
R^2	0.510	0.513	0.526	0.531	0.532	0.537

Note: *, **, and *** show statistical significance at 10%, 5%, and 1% levels, respectively.

3.3.Comparative analysis results

The results of the comparative analysis show that the digital economy reduces inequality within various rural areas in China. Table 5 represents the results of estimating the models for the three eastern, central, and western rural areas. According to Table 5, the digital economy has heterogeneous effects on living standards in various rural areas. The coefficient of the digital economy index is -24.859, which is negative and statistically significant at 1% level in the western rural area, but it is statistically insignificant in the eastern and central areas. This result implies that the digital economy enhances the living standards in the western rural areas more than the other rural areas. In this way, the digital economy narrows the gap between different rural areas since the western rural area is less developed than the central and eastern ones in China.

Furthermore, the results show that the digital economy reduces inequality between rural and urban areas in China. The coefficient of the digital economy index is -8.306 which is negative and statistically significant at 1% level in urban areas, but it is lower than that of the rural areas which is -9.272, negative and statistically significant at 1% level. This comparison indicates that the digital economy affects rural areas more than urban areas, implying that the digital economy narrows the gap between rural and urban areas in China.

Table 5. Results of estimating the nexus of the digital economy index and Engel coefficient in urban and different rural areas of China

	Rural				Urban
	Eastern	Central	Western	Total	Total
DE	-1.044	-2.153	-24.859***	-9.272***	-8.306***
	(-0.23)	(-0.41)	(-5.23)	(-3.73)	(-4.37)
Op	14.325***	3.669	1.613	3.433	8.520***
	(3.12)	(0.45)	(0.35)	(1.44)	(4.67)
St	-0.360***	-0.623***	0.008	-0.133**	-0.154***

	(-2.90)	(-3.69)	(0.07)	(-2.08)	(-3.16)
Y	-0.000	-0.000	0.000	-0.000	0.000
	(-0.45)	(-0.10)	(0.91)	(-1.58)	(0.20)
Ed	0.730***	0.572*	0.328	0.136	0.467***
	(2.92)	(1.89)	(0.85)	(0.80)	(3.61)
Tr	5.052	9.545*	9.947	-4.464*	-3.328*
	(0.99)	(1.91)	(0.70)	(-1.71)	(-1.67)
C				46.396***	35.048***
				(10.24)	(10.11)
R^2				0.537	0.659

Note: *, **, and *** show statistical significance at 10%, 5%, and 1% levels, respectively.

3.4.Mechanism of the effect

The results of the classic three-step test reveal that the digital economy affects living standards by impacting household consumption expenditure. Table 6 represents the results of this test. According to Table 6, the coefficient of the digital economy index is 1.1839 in Equation 7 which is positive and statistically significant at 1% level, implying its considerable effect on household consumption expenditure. In addition, the coefficient of household consumption expenditure is -10.723, which is negative and statistically significant at 1% level, indicating the considerable effect of household consumption expenditure on living standards. These results show that the digital economy increases household consumption expenditure, which in turn heightens living standards. confirming the intermediate role of household consumption expenditure in the effect of the digital economy.

Table 6. Mechanism test results

	Ex	EC
Ex		-10.723***
		(-5.88)
DE	1.183***	3.423
	(15.23)	(1.07)
Op	-0.832***	-5.498**
	(-11.16)	(-2.02)
St	0.012***	0.005
	(6.45)	(0.08)
Y	0.000***	0.000
	(6.41)	(0.56)
Ed	-0.017***	-0.046
	(-3.21)	(-0.28)
Tr	0.309***	-1.148
	(3.79)	(-0.45)
C	0.636***	53.224***
	(4.49)	(12.01)
R^2	0.945	0.589

Note: *, **, and *** show statistical significance at 10%, 5%, and 1% levels, respectively.

3.5.Robustness tests results

The results of the robustness tests confirm the reliability and validity of the conclusions. Table 7 represents the

results of estimating the models after alternating the variables, sample size, and estimation method (OLS). According to Table 7, all the estimated coefficients of the digital economy index are negative and statistically significant at 1% level, which is consistent with the results of estimating Equations 1 to 6. The results of the robustness tests show that the conclusions are stable even if the estimations procedure changes the variables, sample size, or method. Therefore, the conclusions of the estimations are valid and reliable regarding the positive effect of the digital economy on living standards, especially in rural areas.

Table 7. Robustness tests results

	Variable addition	Municipalities deletion	OLS
ED	-8.086***	-13.891***	-15.657***
	(-2.69)	(-5.43)	(-5.12)
Op	4.322	2.774	7.484***
	(1.60)	(1.12)	(4.48)
St	-0.124*	-0.163**	-0.013
	(-1.91)	(-2.27)	(-0.21)
HC	-118.725		
	(-0.70)		
Y	-0.000	-0.000	-0.000
	(-1.64)	(-0.00)	(-1.06)
Ed	0.136	0.529***	0.055
	(0.80)	(2.93)	(0.38)
Tr	-4.283	5.354	-1.551**
	(-1.63)	(1.51)	(-2.03)
C	47.537***	33.615***	39.824***
	(9.86)	(7.70)	(11.26)
Sample size	310	270	310
R^2	0.537	0.558	0.278
Provinces	31	27	31

Note: *, **, and *** show statistical significance at 10%, 5%, and 1% levels, respectively.

DISCUSSION

This paper reveals that the digital economy improves the economic pillar of sustainable development by increasing the living standards in rural areas of China. The digital economy index shows a negative effect on the Engel coefficient, implying a positive effect on living standards. This result is consistent with Zhang et al., (2021), Leng, (2022), Pang et al., (2022), Zhang et al., (2022), Jiang and Jin (2023), Li and Jiang (2023), Oloyede et al., (2023), Wang et al., (2023), and Zhao et al., (2023). However, this finding is inconsistent with Sorgner, (2017), Bessen, (2019), Guellec, (2020), Jetha et al., (2023), and Yang et al., (2023). This effect is considerable not only in whole rural areas but also specifically in western rural areas. In addition, the results confirm this effect in rural areas. Therefore, digitalization improves living standards in various areas of China.

Moreover, this promoting effect improves the social pillar of sustainable development by increasing equality in China. Digitalization reduces the gap of rural and urban areas since it shows a higher positive effect in rural areas than in urban areas. In addition, digitalization has a more dominant effect in less-developed areas like western rural areas of China. In this way, digitalization plays an effective role in improving equality as a social development in China.

CONCLUSION

5.1.Research conclusions

This paper explores how the digital economy affects living standards and equality in China focusing on the rural and urban disparity. This exploration uses fixed effects models to estimate the relationship of the digital economy index with the Engel coefficient between 2011 and 2020.

The results indicate the positive effect of digitalization on the economic and social pillars of sustainable development by improving living standards and equality. According to the findings, the digital economy index reduces the Engel coefficient and increases the living standards in rural and urban areas of China, promoting economic prosperity. Comparatively, this effect is more significant in rural areas, especially the western one which is less developed, narrowing the disparity and improving equality and social development.

5.2.Policy recommendations

From practical viewpoint, this research has some implications, suggesting policymakers expand and develop digitalization, especially within regions with low levels of development. The government should boost and develop digital infrastructure like internet bandwidth, mobile communication, online banking, E-healthcare, agricultural tech, and E-learning. As a result of enhancing digital technology, it can promote economic activities by increasing productivity, job creation market expansion, financial facilitation, and education quality. This development should be more concentrated in rural areas to narrow their gaps with urban people. More specifically, the western rural areas should benefit from such development and structure.

From a theoretical implication perspective, this study has some theoretical contributions to the literature regarding the beneficial impacts of digitalization on living standards specially in rural areas. By revealing a negative connection with the Engel coefficient, it shows that digital economy considerably diversifies the consumption profile beyond basic needs, signifying the leverage of living standards. This impact is more significant in western rural areas in China, highlighting the key role of digital technology in economic development. In addition, the results introduce the digital economy as a strong equalizer to narrow the income gap of urban and rural people. This finding underscores the contribution of the digital economy to social development. Therefore, the findings show that digitalization significantly improves sustainable development goals such as SDG 8 (Decent work and economic growth), SDG 10 (reduced inequalities), and SDG 16 (Peace, justice and strong institutions).

5.3.Research limitations and future prospects

Although this research shows valuable investigation and findings, it assesses some limitations like ignorance of urban disaggregation. This research considers urban areas as a whole and estimates the relationship of the digital economy and living standards using only one model. Future research can estimate this relationship using various models after disaggregating the urban areas. This approach can show which urban area has a priority for further development of digitalization.

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REFERENCES

[1] Bessen, J. (2019). Automation and jobs: when technology boosts employment. Economic Policy, 34(100), 589-626.

[2] Bernik, I., Prislan, K., & Mihelič, A. (2022). Country life in the digital era: comparison of technology use and cybercrime victimization between residents of rural and urban environments in Slovenia. Sustainability, 14(21), 14487. https://doi.org/10.3390 /su142114487

[3] Chen, W., Du, X., Lan, W., Wu, W., & Zhao, M. (2023). How can digital economy development empower high-quality economic development? Technological and Economic Development of Economy, 29(4), 1168–1194. https://doi.org/ 10.3846/ tede.2023.18784

[4] Chen, L., &, Y. (2023). Does the development of the digital economy promote common prosperity? Analysis based on 284 cities in China. Sustainability, 15, 4688. https://doi.org/10.3390/su15054688.

[5] Chetty, K., Aneja, U., Mishra, V., & Josie, J. (2018). Bridging the digital divide in the G20: skills for the new age. Economics E-Journal, 12(1). https://doi. org/10.5018/economics-ejournal.ja.2018-24

[6] Cheng, Y., & Zheng, D. (2023). Does the digital economy promote coordinated urban–rural development? Evidence from China. Sustainability,15(6),5460. https:// doi.org/10.3390/su15065460

[7] Deng, X., Guo, M., & Liu, Y. (2023). Digital economy development and the urban-rural income gap: Evidence from Chinese cities. PLOS ONE, 18(2), e0280225. https://doi.org/10.1371/journal.pone.0280225

[8] Guellec, D. (2020). Digital innovation and the distribution of income. in measuring and accounting for innovation in the twenty-first century (pp. 323-370). National Bureau of Economic Research, Inc.

[9] Hao, N., & Ji, M. (2023). Development of platform economy and urban–rural income gap: Theoretical deductions and empirical analyses. Sustainability, 15(9), 7684. https://doi.org/10.3390/su15097684

[10] Jetha, A., Bonaccio, S., Shamaee, A., Banks, C. G., Bültmann, U., Smith, P. M., Tompa, E., Tucker, L. B., Norman, C., & Gignac, M. A. M. (2023). Divided in a digital economy: Understanding disability employment inequities stemming from the application of advanced workplace technologies. SSM - Qualitative Research in Health, 3, 100293. https://doi.org/10.1016/j.ssmqr.2023.100293

[11] Jiang, C., & Jin, B. (2023). Does the development of digital economy infrastructure reduce the urban-rural income gap? Theoretical experience and empirical data from China. Kybernetes, Advance online publication. ISSN: 0368-492X. https://doi.org/10.1108/K-03-2023-0255

[12] Khan, N. F., Ikram, N., & Saleem, S. (2023). Effects of socioeconomic and digital inequalities on cybersecurity in a developing country. Security Journal. Advance online publication. https://doi.org/10.1057/s41284-023-00416-w

[13] Leng, X. (2022). Digital revolution and rural family income: Evidence from China. Journal of Rural Studies, 94, 336-343. https://doi.org/10.1016/j.jrurstud.2022.07.004

[14] Li, H., & Jiang, H. (2023). Effect of the digital economy on farmers' household income: County-level panel data for Jilin Province, China. Sustainability, 15(5), 4450. https://doi.org/10.3390/su15054450

[15] Li, Z., Liu, C., & Chen, X. (2022). Power of digital economy to drive urban-rural integration: Intrinsic mechanism and spatial effect, from perspective of multidimensional integration. International Journal of Environmental Research and Public Health, 19(23), 15459. https://doi.org/10.3390/ijerph192315459

[16] Liu, B., & Zhou, J. (2023). Digital literacy, farmers' income increase and rural internal income gap.

Sustainability, 15(14), 11422. https://doi.org/10.3390/su151411422

[17] Liu, J. (2017). An empirical study on the continuous widening of urban-rural digital divide between urban and rural income gap. Statistics & Decision, 33(10), 119-121. https://doi.org/10.13546/j.cnki.tjyjc.2017.010.030

[18] Lu, L., Guan, J., & Wu, X. (2022). Factors influencing the development of digital economy in local areas of China based on big data statistics. Volume 2022, Article ID 5034867. https://doi.org/10.1155/2022/5034867

[19] Laskar, M. H. (2023). Examining the emergence of digital society and the digital divide in India: A comparative evaluation between urban and rural areas. Frontiers in Sociology, 8, 1145221. https://doi.org/10.3389/fsoc.2023.1145221

[20] Nasrollahi, Z., Hashemi, M.-S., Bameri, S., & Tahgvaee, V. M. (2020). Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: Using STIRPAT model. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-018-0237-5

[21] Nijman, J., & Wei, Y. D. (2020). Urban inequalities in the 21st century economy. Applied Geography, 117, 102188. https://doi.org/10.1016/j.apgeog.2020.102188

[22] Nodehi, M., Arani, A. A., & Tghvaee, V. M. (2022). Sustainability spillover effects and partnership between East Asia & Pacific versus North America: interactions of social, environment and economy. Letters in Spatial and Resource Sciences, 15(3), 311–339. https://doi.org/10.1007/s12076-021-00282-5

[23] Oloyede, A. A., Faruk, N., Noma, N., Tebepah, E., & Nwaulune, A. K. (2023). Measuring the impact of the digital economy in developing countries: A systematic review and meta-analysis. Heliyon, 9(7), e17654. https://doi.org/10.1016/j.heliyon.2023.e17654

[24] Pang, J., Jiao, F., & Zhang, Y. (2022). An analysis of the impact of the digital economy on high-quality economic development in China—a study based on the effects of supply and demand. sustainability, 14(24), 16991. https://doi.org/10.3390/su142416991

[25] Qiu, Y., He, N., Yan, C., & Rao, Q. (2023). Whether the digital divide widens the income gap between China's regions? PLoS One, 18(2), e0273334. https://doi.org/10.1371/journal.pone.0273334

[26] Qin, F., Wang, J., & Xu, Q. (2022). How does the digital economy affect farmers' income?—Evidence from the development of rural e-commerce in China. China Economic Quarterly, 22, 591-612.

[27] Redshaw, T. (2020). What is a digital society? Reflections on the aims and purpose of digital sociology. SAGE J., 54, 114. https://doi.org/10.1177/0038038519880114

[28] Rosário, A. T., & Dias, J. C. (2023). The New digital economy and sustainability: Challenges and opportunities. Sustainability, 15(14), 10902. https://doi.org/10.3390/ su151410902

[29] Shirazi, J. K., Tavaee, V. M., Nasiri, M., & Assari Arani, A. (2020). Sustainable development and openness in oil-exporting countries: green growth and brown growth. Journal of Economic Structures, 9(1). https://doi.org/10.1186/s40008-020-00216-2

[30] Soretz, S., Nodehi, M., & Mohamad, V. (2023). Sustainability and sustainable development concepts: Defining the perspectives and pillars. Reference Module in Social Sciences. Elsevier. ISBN 9780443157851. https://doi.org/10.1016/B978-0-44-313776 -1.00030-1.

[31] Sorgner, A. (2017). The Automation of Jobs: A threat for employment or a source of new entrepreneurial opportunities? Foresight and STI Governance (Foresight-Russia till No. 3/2015), 11(3), 37-48.

[32] Tiwasing, P., Clark, B., & Gkartzios, M. (2022). How can rural businesses thrive in the digital economy? A UK perspective. Heliyon, 8(10), e10745. https://doi.org/ 10.1016/j.heliyon.2022.e10745

[33] Wang, J., & Xu, Y. (2023). Digitalization, income inequality, and public health: Evidence from developing countries. Technology in Society. Advance online publication. https://doi.org/10.1016/j.techsoc.2023.102210

[34] Wang, Y., Peng, Q., Jin, C., Ren, J., Fu, Y., & Yue, X. (2023). Whether the digital economy will successfully encourage the integration of urban and rural development: A case study in China. Chinese Journal of Population, Resources and Environment, 21(1), 13-25.

[35] Xu, M. (2022). Analysis of problems of digital economy for rural construction in Guangxi. In Proceedings of the 2022 2nd International Conference on Economic Development and Business Culture (ICEDBC 2022) (pp.124). DOI: 10.2991/978 -94-6463-036-7_124

[36] Yang, G., Yao, S., & Dong, X. (2023). Digital economy and wage gap between high- and low-skilled workers. Digital Economy and Sustainable Development, 1, Article 7. https://doi.org/10.1007/s42812-023-00033-9

[37] Yin, Z., Jiang, J., & Yan, Y. (2021). Does the digital divide affect household income? Finance & Trade Economics, 43(9), 66-82. https://doi.org/10.19795/ j.cnki.cn11-1166/f.20210915.007

[38] Zhang, C., Tian, X., Yang, X., Xu, B., & Li, Q. (2022). The iron-out effect of digital economy: A discussion on gender wage rate discrimination for working hours. Journal of Business Research. Advance online publication. https://doi.org/10.1016/ j.jbusres.2022.113399

[39] Zhang, W., Zhao, S., Wan, X., & Yao, Y. (2021). Study on the effect of digital economy on high-quality economic development in China. PLoS One, 16(9), e0257365. https://doi.org/10.1371/journal.pone.0257365

[40] Zhao, T., Jiao, F., & Wang, Z. (2023). Digital economy, entrepreneurial activity, and common prosperity: Evidence from China

[41] Zhonglin, W., Testing and application of the mediating effects. Acta Psychologica Sinica, 2004. 05: p. 614-620.(in Chinese)

Appendix

Table A-1- Sub-indexes of the digital economy index

Second-level Index	Three-level Index
Internet penetration rate	Internet users
Number of Internet-related employees	Computer services and software workers
Internet-related output	Total number of telecom services per capita
Number of mobiles	Number of mobile phones per 100 people
Internet users	China's digital financial inclusion index
Inclusive development of digital finance	