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Digital economy and rural household resilience: Evidence from China

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Abstract: Enhancing the resilience of rural households against the impacts of risks and moulding their enduring strength despite modest scale holds paramount contemporary significance for a multitude of developing nations, including China. This study uses the microdata of the China Labor-Force Dynamics Survey (CLDS), systematically measures the rural household resilience index for the first time, analyses the impact of the digital economy on the resilience of rural households, and dissects the group differences and mechanism of action. We found that from 2012 to 2018, the Chinese rural household resilience index had significant differences in time and space, and village market, gentry assistance, economic organisation, and income from collective operation were the most important indicators affecting the rural household resilience index. The improvement of the digital economy index, to some extent, suppressed the improvement of the rural household resilience index. Meanwhile, heterogeneity analysis suggested that depending on family size and housing property rights, the impact of the digital economy on the resilience of rural households will be divided. Moreover, mechanism analysis showed that the digital economy further affected the resilience of rural households through the employment comprehensive effect, income structure effect and member security effect.

Keywords: China Labor-Force Dynamics Survey; digital technology; index system; random forest algorithm; resilience measurement

In 2020, China achieved the goal of eradicating absolute poverty in rural areas, securing a comprehensive victory in the fight against poverty. As a result, the focal point of the 'three rural' (agriculture, countryside, and farmers) works underwent a historic shift. However, one should be cautious as the eradication of absolute poverty did not fundamentally alter the inherent vulnerability of small farming households. Rural areas, especially those recently lifted out of poverty, still face challenges such as low development quality, weak industrial foundations, limited human capital, and inadequate resilience against external risks and challenges, posing real risks of falling back into poverty. Hence, during this critical period of consolidating and expanding the achievements in poverty alleviation, it is of great practical significance to construct a comprehensive indicator system objectively assessing rural household resilience to uncertainty shocks.

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Scholars' research on rural household resilience mainly revolves around three aspects: the connotation and evolution of rural household resilience, the measurement of rural household resilience, and the influencing factors of rural household resilience. Firstly, the connotation and evolution of rural household resilience: In recent years, resilience in the 'three rural' areas has been primarily studied concerning rural resilience (McManus et al. 2012; Spector et al. 2019; Li 2023), agricultural resilience (Gardner et al. 2019; Dardonville et al. 2020; Rathi 2022), and poverty alleviation (Lade et al. 2017; Desmond and Western 2018; Bruckner et al. 2022). Among them, scholars have described rural household resilience as the opposite of vulnerability for small farming households. It refers to these households exhibiting 'fragility without breaking and weakness without perishing' when interacting with the external environment, particularly when facing various pressures, along with the determination and ability to achieve sustainable survival and development (Gupta et al. 2021; Milhorance et al. 2022). Secondly, the measurement of rural household resilience: A review of relevant literature reveals a wealth of research measuring rural (economic) resilience from the perspective of regional economic resilience (Farahani and Jahansoozi 2022; Su et al. 2022; Zhou et al. 2023). Thirdly, the influencing factors of rural household resilience: Against the backdrop of common prosperity and rural revitalisation, rural households face both development opportunities and external challenges. Thus, the analysis of various factors affecting rural household resilience has garnered considerable attention in academia (Cox and Hamlen 2015; Cutter et al. 2016; Liu et al. 2023). As China's digital economy enters the fast lane of development, data is gradually becoming a new production factor driving economic and social development. The improvement in data availability, enhanced data mobility, and increased predictive decision-making capabilities are profoundly influencing and reshaping traditional industries and human society. Some scholars have conducted relevant research on the impact of the digital economy on agricultural resilience (Ramda 2020; Almunawar et al. 2023).

Clearly, existing research has focused on the impact of the digital economy on agricultural resilience without specifically targeting the resilience of rural household units. However, discussing resilience issues in Chinese agriculture, where small-scale farming is the predominant form of operation, from the perspective of individual rural households cannot be understated in its importance. It is for this reason that gaps in this field still exist that warrant further exploration. Firstly, existing research predominantly concentrates on the resilience assessment at the macro level of agriculture and rural contexts, exhibiting a notable deficiency in the analysis of resilience at the micro level of individual farm households. Secondly, contemporary scholarly analyses often confine themselves to singular dimensions, such as the economic resilience of rural households. There is a notable absence of comprehensive exploration from a holistic perspective and across diverse dimensions concerning the integrated resilience of rural households. This shortfall extends to examining constituent elements, evolutionary traits, and spatial relationships. Thirdly, the role of the digital economy in shaping rural household resilience and the underlying mechanisms of its formation remain inadequately expressed and insufficiently scrutinised within the context of this pertinent issue aligned with the characteristics of the digital era.

The purpose of this paper is to analyse the impact of the digital economy on rural household resilience and examine group differences and mechanisms on the basis of systematically calculating the rural household resilience index for the first time so as to provide reasonable suggestions for accelerating rural revitalisation and promoting the modernisation of agriculture and rural areas in China.

Theoretical analyses and research hypothesis

Direct impact mechanism of the digital economy on rural household resilience. The classic depiction of 'fragile farmers' has its limitations, and it requires us to redefine small farming households with a new understanding, which we can refer to as 'resilient farmers'. Under the backdrop of the digital economy, digital embedding profoundly alters the fundamental situation of farmers in terms of adaptability, stability, absorptive capacity, flexibility, and assistance, consequently affecting the resilience of their households. Therefore, this paper proposes H_1:

H_1: The digital economy has a significant impact on the resilience of rural households.

Indirect transmission mechanism of the digital economy affecting rural household resilience. The digital economy is profoundly impacting the transformation of the job market. This phenomenon brings both significant opportunities for job creation and significant challenges due to job displacement, which will inevitably further influence the resilience of rural households. Therefore, H_2 is proposed:

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H_2: The digital economy significantly impacts rural household resilience through its comprehensive effect on employment.

The digital economy has changed the traditional characteristic of farmers having limited access to non-agricultural work, thus eliminating the isolation between farmers and the non-agricultural job market. It has become an essential means to improve the income structure of rural households. Therefore, H_3 is proposed:

H_3: The digital economy significantly impacts rural household resilience through its effect on income structure.

Family is the basic unit of society, and rural households commonly have multiple functions such as agricultural production, child education, and support of the elderly. The digital economy may impact the family roles of left-behind women and the rearing costs of left-behind children as well as left-behind elderly. During this process, family resilience may also undergone significant transformations. Therefore, H_4 is proposed:

H_4: The digital economy significantly impacts rural household resilience through its effect on family members' security.

MATERIAL AND METHODS

A brief review of resilience measurement. Resilience measurement should explain the capability of households to absorb the negative effects of unpredictable shocks rather than to predict the occurrence of a crisis (Alinovi et al.2010). The most recent and diffused measurement methodologies consider resilience as a latent variable derived from a set of observable context-specific dimensions. From those approaches, the Food and Agriculture Organization (FAO)'s Resilience Index Measurement and Analysis Model (RIMA I, subsequently updated to RIMA II) is the longest-standing methodology (Alfani et al. 2015), constantly evolving and being tested under different geographical contexts. Under the RIMA-II methodology, the Resilience Capacity Index (RCI) relies on four attributes called pillars: assets (AST), access to basic services (ABS), social safety nets (SSN), and adaptive capacity (AC). The RIMA II model is a dynamic methodology that uses a mixed-methods approach and allows for context adaptation and rigorous analysis and comparison of the households, their adopted coping strategies to shocks and stressors, and the effects of such shocks on the households' resilience, thus a providing a better understanding of the households and their needs, and a subsequent assistance improvement. However, the RIMA II model lacks measurement of the characteristics of internal family relationships and internal village relationships. Both family relationship networks and village relationship networks play roles in resource and information transmission, enabling families to escape the constraints of resource scarcity and information deficiency. Investigating the impact of this dual relationship network on household resilience is an important aspect of this study.

The R4 Initiative is a comprehensive risk management initiative developed in partnership between the World Food Programme (WFP) and Oxfam that aims at increasing communities' food and income security and resilience to climate variability and shocks. R4 seeks to build households' and communities' resilience by reinforcing their abilities to withstand stresses, shocks, and disruptions while maintaining their essential functions and incrementing the capacities to recover quickly and to go back to a previous or a better and stronger state in an effective manner (Lascano Galarza 2020). R4 aims to create a social safety net for the beneficiary communities based on four risk management strategies: risk reduction, risk transfer, prudent risk-taking (credit) and risk reserve (savings). Unfortunately, R4 emphasises the adaptive characteristics of families during risk periods while lacking characterisation of family behaviour during non-risk periods, namely stability characteristics. Moreover, the evaluation indicators in R4 mainly consist of monetary indicators, making it difficult to quantify some informal characteristics.

Another classic approach is the Strategic Resilience Assessment process (STRESS) developed by Mercy Corps. Mercy Corps define resilience as the capacity to learn, cope, adapt and transform in the face of shocks and stresses. Capacities can be absorptive (helping people, households or systems to better prepare for or recover from existing shocks and stresses), adaptive (mitigating the presence or nature of shocks and stresses over time), or transformative (enhancing the enabling environment to maximise access to and use of absorptive or adaptive capacities). STRESS was designed to analyse the dynamic social, ecological and economic systems in rural and urban areas within which communities are embedded, how these conditions determine vulnerability to shocks and stresses, and social and economic well-being outcomes (Mercy Corps 2015). Mercy Corps' STRESS is one of the few methods that describe the characteristics and evolution of resilience from the perspective of the family unit. However, its characterisation of household resil-

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ience features is still somewhat rough, such as differences in how families seek external assistance.

Despite the greater interest in the topic, no consensus on the concept of resilience of rural households has been achieved, nor is there any agreement on the appropriate measurement. There is an active attempt to create a unique set of resilience indicators through a review of current global best practices and the growing literature on the topic (Serfilippi and Ramnath 2018). Thus, we propose a set of resilience indicators carefully distilled from the resilience frameworks mentioned above. The approach used to classify the indicators balances a multi-dimensional view based on the dynamic resilience capacities (adaptability, stability, absorptivity, flexibility, and assistance) with static social, environmental, and economic (SEE) dimensions in order to capture the complexity of factors relevant to measuring rural household, in line with the Sustainable Livelihood Framework (SLF) authored by the Department for International Development (DFID). In a word, we strive to highlight the unique characteristics of Chinese small-scale farmers while maintaining generality.

Variable measurement. The core explanatory variable in this study is the Digital Economy Index. Grounded in the essence of the digital economy and insights from the approaches proposed by scholars such as Mesenbourg (2001) and Barefoot et al. (2018), this paper focuses on the conditions, applications, and milieu of the digital economy, comprehensively constructing a system of digital economic indicators. Specifically, the comprehensive index of the digital economy serves as the ultimate goal. Three dimensions, namely, digital economy infrastructure, digital industrialisation and industrial digitalisation, are established based on the connotation of the digital economy and the current context. These dimensions reflect the macro-level prerequisites for the digital economy, the development of ICT industries and the convergence of digital industries. Within this framework, nine sub-indicators are selected, representing traditional and new digital infrastructure as carriers of digital economic development, the scale and variety of industries as indicators of digital industrialisation, as well as the digitisation of agriculture, industry, and services as aspects of industrial digitisation. The selection of variables was guided by principles of scientific rigour, hierarchical relevance, and data accessibility, resulting in the incorporation of 30 variables (Table 1).

According to the five characteristics of 'resilient farmers' (adaptability, stability, absorptivity, flexibility, and assistance), we selected 20 indicators (Table 2) to measure the level of rural household resilience. Specifically, adaptability refers to the ability of households to survive in changing external environments; stability denotes the capacity of households to maintain their existence and continuity under external pressures; flexibility signifies the ability of households to take appropriate measures in complex and changing circumstances; absorptivity refers to households' capability to secure survival and continuity through external energy absorption; and lastly, assistance reflects the capacity of households to seek external aid for survival and continuity during times of adversity.

Typically, most research, particularly concerning rural households, tends to select control variables from the individual, household, and village dimensions provided by the China Labor-Force Dynamics Survey (CLDS) questionnaires. Hence, given that we did not utilise the individual questionnaire in our study, we followed the customary practice of CLDS research and selected control variables from the household and village dimensions, with insights from existing literature (Deng et al. 2020; Qin et al. 2020; Huang et al. 2023; Ma et al. 2024).

Household characteristics included household economic status, household environmental condition, household pensions or retirement fund, household debts and household education expenditures. Specifically, household economic status emphasises the social and economic position of the family, representing subjective perceptions built upon objective foundations and serving as a gauge of household resilience. Household environmental conditions, as a microsystem within the environment, constituted the immediate environment for individual activities and interactions with others. The stability and orderliness of household environmental conditions are crucial for the development of household resilience. Household pensions or retirement funds, along with household debts, function as reserves for the family, reflecting the family's emergency response capability and ability to withstand risk shocks. The increase in household education expenditures facilitates the rapid accumulation of human capital, ultimately leading to higher levels of resilience.

Village characteristics included the total administrative area of the village, neatness of the village appearance, number of village enterprises, location conditions of the village (measured by the distance to the nearest county/city government) and village security conditions. Specifically, the compatibility between the administrative area of the village and regional endowments is a crucial aspect of achieving stable improvements in the living standards of rural households.

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Table 1. Measurement system of digital economy index

First-level indicators	Second-level indicators	Third-level indicators	Indicator attribute
Digital economy infrastructure	traditional infrastructure	number of Internet users	+
		number of Internet broadband access users	+
		number of domain names	+
		number of sites	+
	new digital infrastructure	investment in fixed assets in information transmission, software and information technology services	+
		mobile phone switch capacity	+
		cable line length	+
	rural digital infrastructure	rural Internet penetration	+
		rural smartphone penetration	+
		number of agrometeorological observation stations	+
Digital industrialization	industrial income	software product revenue	+
		information technology services revenue	+
		embedded systems software revenue	+
		Telecommunications business revenue	+
	industry scale	number of units in the software and information technology industry	+
		number of employees in the software and information technology industries	+
	industrial innovation	full-time equivalent of R&D personnel	+
		R&D funding intensity	+
		number of high-tech enterprises	+
		number of technical contract registration	+
Industrial digitalization	digitalization of agriculture	investment in agricultural production	+
		the proportion of administrative villages that have opened Internet broadband services	+
		online retail sales of agricultural products	+
		number of Taobao village	+
	digitalization of industry	number of manufacturing enterprises in the electronic information industry	+
		total industrial output value of the electronic information manufacturing industry	+
		finished goods inventory of the electronic information manufacturing industry	+
	digitalization of service	e-commerce sales	+
		proportion of enterprises engaged in e-commerce transaction activities	+
		digital financial inclusion index	+

Source: Authors' own processing

Apart from the natural evolution of villages, China has also undertaken various degrees of adjustments to the scale of administrative villages, yielding results while facing numerous resistances and challenges. The neatness of the village's appearance is an integral component of the rural territorial system and serves as the

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Table 2. Measurement system of rural household resilience index

First-level indicators	Second-level indicators	Indicator symbol	Variable description	Indicator attribute
Adaptive characteristics	land area	*LA*	number of acres of household land	+
	part-time income	*PI*	total household wage income (or non-agricultural operational income)	+
	village topography	*VT*	village topography	–
	village greenery	*VG*	village green coverage	+
Stability characteristics	agricultural labour force size	*ALFS*	number of households engaged in agricultural production	+
	family relationship	*FR*	relationships between family members	+
	collective income	*CI*	village collective financial revenue	+
	clan size	*CS*	proportion of the largest surname in village population	+
Flexibility characteristics	cropping pattern	*CP*	family land farming type	+
	expenditure pattern	*EP*	family Engel coefficient	–
	economic organisation	*EO*	types of village economic organizations	+
	information dissemination	*ID*	main way for village committees to disseminate information to villagers	+
Absorptive characteristics	Internet usage	*IU*	cost of the Internet spent by the family using the computer	+
	electricity availability	*EA*	electricity in the home	+
	farm machinery quantity	*FMQ*	number of household tractors and large farm implements	+
	rural markets	*RM*	types of village markets	+
Assistance characteristics	blood-related assistance	*BA*	remittance income from family relatives	+
	gentry assistance	*GEA*	amount of donations to the village by people who have traveled from the village	+
	villager mutual assistance	*VMA*	degree of harmony between villagers	+
	government assistance	*GOA*	proportion of hardened pavement in village	+

Source: Authors' own processing

foundation for agricultural production, rural ecology, and farmer livelihoods, with its quality directly impacting the welfare of numerous rural households. Village enterprises represent economic industries under specific historical policies in China, serve as the main provider of non-agricultural employment for rural residents and play a significant role in increasing rural household income. Meanwhile, in the process of urbanisation, the relationship between farmers and the market is defined based on market location conditions. For farmers, the market embodies both opportunities and the potential for increased pressure. Under different location conditions of the village, there are significant differences in the configuration logic of household resilience. The prosperity of rural communities relies on village security conditions. Social insecurity disrupts cultural development and public order, leading to a lack of security among villagers, which is detrimental to the enhancement of household resilience.

Data source. The construction of the digital economy index in this paper was based on macro-level indicators at the provincial level. The data primarily originated from the National Bureau of Statistics of China (2012–2018), Department of Rural Surveys of National Bureau of Statistics of China (2012–2018), State Information Center of China (2012–2018), AliResearch (2020) and the Institute of Digital Finance of Beijing University (2021). The rural household resilience index was constructed using micro-level indicators at the

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household level. The data mainly came from the China Labor-force Dynamics Survey (CLDS) for 2012, 2014, 2016, and 2018. Descriptive statistical results of the variables are presented in Table 3.

Research methods. Entropy, originating from the thermodynamic concept in physics, primarily denotes the degree of disorder in a system. It has now found widespread application in areas such as sustainable development assessments and socio-economic research (Delgado and Romero 2016; Feng and Gong 2020; Kumar et al. 2021). In digital economy research, Erkhembaatar (2023) used it to construct the ICT development index, and in the realm of rural household resilience research, Khatibi et al. (2019) once employed it to assess the resilience to drought of rural communities in Iran. Thus, in order to avoid the inaccuracy caused by subjective weighting, this study employed the entropy weighting method to calculate the Digital Economy Index and Rural Household Resilience Index:

$$RHRI_{ij} = \sum_{j=1}^{m} h_j \times w_{ij} \quad (1)$$

where: $RHRI_{ij}$ – rural household resilience index of province i in year j, ranging from 0 to 1; w_{ij} – weight of each indicator; h_j – proportion of each indicator; m – number of covered years.

The provincial rural household resilience index was obtained by calculating the average or median of the resilience scores of all rural households within the same province. The calculation method for the Digital Economic Index (DEI_{ij}) was similar and will not be reiterated.

Random forest is an emerging approach for prediction through statistical or machine learning algorithms.

Table 3. Descriptive statistics of the variables (10 722 observations)

Variable name	Variable description	Mean	SD	Minimum	Maximum
Rural household resilience index	calculated by the entropy method	0.0708	0.0401	0.0133	0.3819
Digital economy index	calculated by the entropy method	0.1384	0.1434	0.0105	0.6616
Household economic status	ordered integer of 1~10, representing from poor to rich	5.2916	1.7565	1.0000	10.0000
Household environmental condition	ordered integer of 1~10, representing from dirty to tidy	5.8798	1.7820	1.0000	10.0000
Household pensions or retirement fund	family divorce or retirement income in 2017, plus 1 to take the natural logarithm	0.4558	1.9224	0.0000	12.2259
Household debts	total amount of money owed (borrowed) by the household, plus 1 to take the natural logarithm	3.5327	4.8487	0.0000	18.4207
Household education expenditures	family education expenditure (including the sum of all education expenses for adults and children) in 2017, plus 1 to take the natural logarithm	4.1359	4.2476	0.0000	12.2061
Total administrative area of the village	total administrative area of the village, taken as the natural logarithm	1.5427	1.3972	–5.8091	6.6846
Neatness of the village appearance	ordered integer of 1~10, representing from dirty to tidy	7.1180	1.6954	1.0000	10.0000
Number of village enterprises	number of enterprises (excluding shops and supermarkets) in the administrative area of the village, plus 1 to take the natural logarithm	0.5476	0.9501	0.0000	5.7071
Location conditions of the village	distance from the nearest county or district government to the village, plus 1 to take the natural logarithm	3.0110	0.8488	0.0000	5.7071
Village security conditions	1 = very good, 2 = good, 3 = fair, 4 = not good, 5 = poor	4.3604	0.6757	1.0000	5.0000

Source: Authors' own processing

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Considering the nonlinear relationships within data, this method has gained widespread application in the field of agricultural and applied economics (Kleinberg et al. 2015, 2018; Athey and Imbens 2019; Bandiera et al. 2020; Storm et al. 2020), with promising predictive outcomes, fueled by the advancements in big data technologies. In a recent illustrative example, some scholars used a random forest machine learning model to assess the impacts of combined agricultural input shocks on crop yields globally (Ahvo et al. 2023). Here, we introduce the Out-of-Bag (OOB) concept in random forest. During training, the error of random forest was approximated by the OOB error. Leveraging the OOB error, the random forest algorithm enabled the ranking of variable importance.

To investigate the direct mechanism through which the digital economy influences rural household resilience, this paper established the following baseline model:

$$RHRI_{ijk} = \beta_0 + \beta_1 DEI_{ijk} + \beta_2 X_{ijk} + \gamma_i + \delta_j + \varepsilon_{ijk} \quad (2)$$

where: $RHRI_{ijk}$ – resilience index of rural household k located in province i during year j; DEI_{ijk} – provincial-level digital economy index attained by rural household k in province i during year j; X_{ijk} – set of control variables; γ_i – province fixed effect; δ_j – year fixed effect; ε_{ijk} – random disturbance term.

RESULTS AND DISCUSSION

Analysis of rural household resilience index. Figure 1 depicts the results of the calculated rural household resilience indices for 26 provinces in China for 2012, 2014, 2016, and 2018, as determined through the aforementioned entropy weighting method. Due to data limitations, the analysis excludes the regions of Tianjin, Shanghai, Hainan, Qinghai, and Tibet, as well as Hong Kong, Macau, and Taiwan. Moreover, there are gaps in the data for certain years in Beijing, Chongqing, Ningxia, and Xinjiang. It is evident that the rural household resilience indices exhibited significant temporal and spatial variations. In terms of temporal evolution, from 2012 to 2018, the resilience indices of rural households across various regions in China displayed an overall fluctuating upward trend. This trend underscores the substantial improvement in rural households' living conditions and quality of life attributed to proactive government support and the diligent efforts of rural households themselves. This advancement has largely shed the longstanding stereotype of 'fragile small-scale farmers'. Rural households showed enhanced adaptability to complex external changes, continuously absorbing beneficial external energy, thus achieving resilience for renewal and continuation. This trend aligns with scholars' consensus on the evaluation of the rural reform process in China (Fan et al. 2004; Chen 2019; Xue et al. 2021). Regarding spatial distribution, the rural household resilience indices across different regions in China exhibited a clustered distribution pattern. Strongly resilient rural households were predominantly concentrated in the eastern coastal and Yellow River middle and lower reaches regions. In contrast, weaker resilience was more prevalent in the western inland areas. This spatial pattern was partially related to the local natural endowment conditions and economic development levels.

Furthermore, this study utilised the random forest algorithm to identify the significant importance levels of various indicators contributing to the rural household resilience index (as shown in Figure 2). In terms of the ranking of importance, the top four indicators included rural markets (*RM*), gentry assistance (*GEA*), economic organisation (*EO*), and collective income (*CI*), all of which exhibited importance coefficients exceeding 0.5. These results underscored that marketisation, organisation, and collectivisation not only enhanced the internal capacity of household production but also created unprecedented favourable external environments for development (Lin 1990; Oi 1999; Fang and Dewen 2003). These aspects constitute feasible pathways to further strengthen and elevate the rural households' resilience. Conversely, the three indicators ranked towards the lower end were agricultural labor force size (*ALFS*), electricity availability (*EA*), and family relationship (*FR*), all of which held influence coefficients below 0.2. This result indicated that the development of rural infrastructure, coupled with the introduction of capital, technology, entrepreneurial talent, and other production factors, gradually liberated vast rural households from the inefficient production model overly reliant on labour (Hebel 2003; Fan and Zhang 2009; Gao et al. 2020). It paves the way towards intensive and efficient modern agricultural development.

Benchmark regression analysis. The results of the benchmark regression are presented in Table 4. Column (1) shows the regression results with no control variables, column (2) shows the regression results with only household characteristic control variables, while column (3) includes all control variables related to both household and village characteristics. The regression results indicated that the estimated coefficient of the

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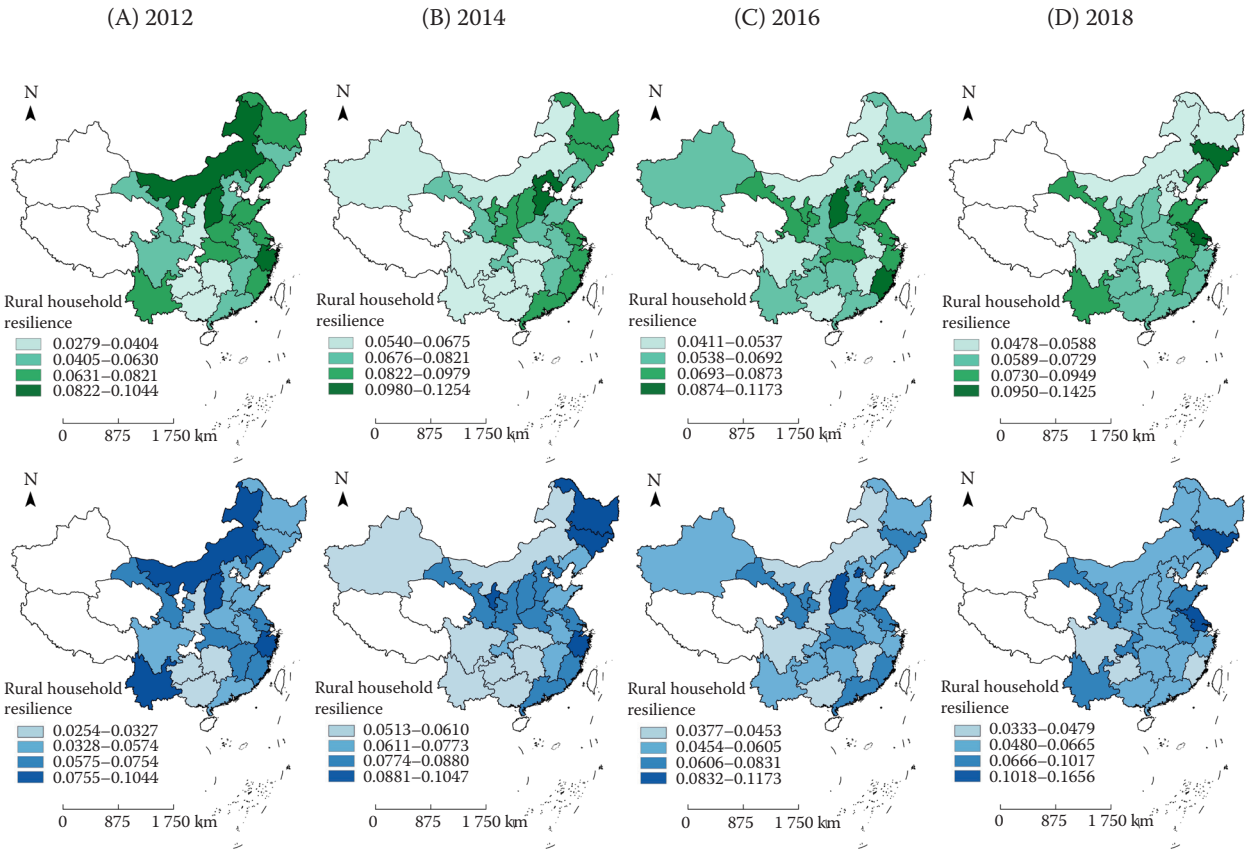

Figure 1. Rural household resilience index of 26 provinces in 2012, 2014, 2016 and 2018

The upper part displays the provincial-level rural household resilience index using the average values, while the lower part displays the same index using median values. As the index calculation does not include control variables, the sample size has increased to 12 601 households compared to the mixed cross-sectional data.

Source: Authors' own processing

core explanatory variable, the digital economy index, was negative and statistically significant at the 5% level. This implies that a higher level of digital economic development in the region where households were located was associated with a lower level of household resilience. Specifically, taking the results from column (3) as an example, for each 1-unit increase in the digital economy index, the household resilience index was estimated to decrease by approximately 0.03 units. This suggests that the current state of the digital economy does not effectively enhance household resilience. Our result contradicts the findings of some scholars such as Kumar (2012), Adera et al. (2014), and Cai et al. (2023), highlighting the hidden issue of the 'digital divide' behind the development of the digital economy (Philip and Williams 2019; Marshall et al. 2020; Peng and Dan 2023). Despite the rapid development of China's digital infrastructure and network terminal devices, the coverage and accessibility of the digital economy have greatly improved. However, behind the access to digital technologies such as internet usage, smartphones, and broadband, there still exists a significant gap in the digital skills of different groups. Therefore, not everyone can fully benefit from the information dividends brought by the digital economy. In theory, the existence of the digital divide not only increases the costs of information collection and dissemination, leading to financial exclusion and difficulty in accessing financing but also hinders interpersonal networks and suppresses social capital. Consequently, it hampers the effective realisation of the welfare effects of poverty reduction and income increase brought about by the digital economy, ultimately impeding the effective enhancement of rural household resilience. Hence, during the initial stage of digital economic development, the presence of the digital divide does not necessarily increase the resilience level of rural households. It is only when the digital economy develops

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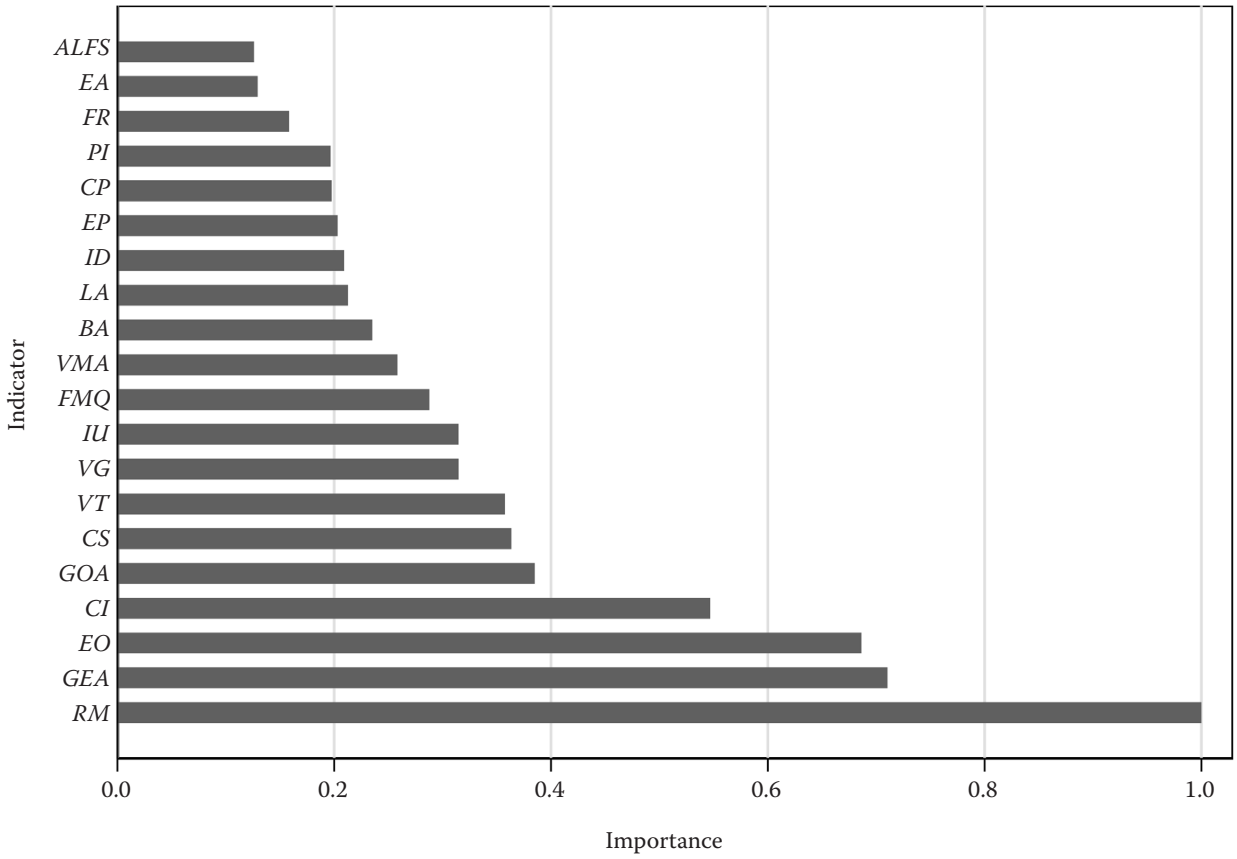

Figure 2. Random forest algorithm visualization of the constituent indicator importance in the rural household resilience index; the sample size is 12 601 households

ALFS – agricultural labour force size; *EA* – electricity availability; *FR* – family relationship; *PI* – part-time income; *CP* – cropping pattern; *EP* – expenditure pattern; *ID* – information dissemination; *LA* – land area; *BA* – blood-related assitance; *VMA* – villager mutual assistance; *FMQ* – farm machinery quantity; *IU* – Internet usage; *VG* – village greenery; *VT* – village topography; *CS* – clan size; *GOA* – government assistance; *CI* – collective income; *EO* – economic organisation; *GEA* – gentry assistance; *RM* – rural markets

Source: Authors' own processing

to a certain extent that it can penetrate rural areas. At this point, rural digitisation construction and the level of digital technology application among residents improve, allowing the benefits of the digital economy to be widely enjoyed by rural households. Overall, the regression results validate H_1.

Robustness test. Given the substantial size of the sample data and to mitigate the potential impact of outliers on regression outcomes, we initially conducted a two-tailed trimming of the sample at the 10th and 90th percentiles [Table 5, column (1)]. Similar to the benchmark regression results, an increase in the digital economy index was found to lower rural household resilience levels.

Secondly, following the method proposed by Bai (2009), the interaction fixed effect not only included the individual fixed effect but was also more stringent than the individual fixed effect. Interaction fixed effect can control for the influence of factors at the provincial and temporal levels on the dependent variable, thus mitigating omitted variable bias. Therefore, in addition to the benchmark regression, we incorporated interaction fixed effects of province and year. As shown in column (2) of Table 5, the regression results remained robust even after controlling for interaction fixed effect.

Thirdly, recognising the differences between municipalities directly under central government administration and provincial-level data in terms of administrative hierarchy, economic structure, and taxation methods, we re-conducted regressions after excluding the four municipalities (Beijing, Tianjin, Shanghai, Chongqing) to test the impact of the digital economy [Table 5, col-

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Table 4. Benchmark regression results

Variable	(1)	(2)	(3)
Digital economy index	0.0253** (0.0129)	–0.0255** (0.0130)	–0.0318** (0.0129)
Household economic status	–	0.0020*** (0.0003)	0.0020*** (0.0003)
Household environmental condition	–	–0.0005* (0.0003)	–0.0007** (0.0003)
Household pensions or retirement fund	–	0.0003 (0.0002)	0.0004 (0.0002)
Household debts	–	0.0002* (0.0001)	0.0002** (0.0001)
Household education expenditures	–	0.0002* (0.0001)	0.0001 (0.0001)
Total administrative area of the village	–	–	–0.0014*** (0.0003)
Neatness of village appearance	–	–	0.0014*** (0.0002)
Number of village enterprises	–	–	0.0068*** (0.0005)
Location conditions of the village	–	–	0.0013*** (0.0005)
Village security conditions	–	–	0.0021*** (0.0006)
Constant	0.0581*** (0.0119)	0.0494*** (0.0118)	0.0316*** (0.0119)
Province fixed effect	yes	yes	yes
Year fixed effect	yes	yes	yes
R^2	0.1113	0.1176	0.1434
Observation	10 722	10 722	10 722

*, **, *** significant at the 10%, 5%, and 1% levels, respectively; standard errors in parentheses.

Source: Authors' own processing

umn (3)]. The robustness of these results was consistent with the benchmark regression outcomes.

Fourthly, we excluded relatively stable indicators from the rural household resilience index (those less susceptible to the digital economy), including land area, village topography, village greenery, and clan size. Subsequently, we recalculated the index based on the remaining indicators and incorporated it into the regression equation as a new robustness check. We found that the deviation from the benchmark regression results was minimal [Table 5, column (4)].

Furthermore, we recalculated the index for both the digital economy and rural household resilience using three different approaches: entropy weight-TOPSIS (technique for order preference by similarity to ideal solution) method, principal component analysis, and the two-step factor method utilised by Ragnedda et al. (2020) in designing the digital capital framework. The recalculated index values and the trend of variation remained largely consistent with those using the entropy weighting method. Then, we conducted additional regression analysis using the index derived from these alternative calculation methods. The regression coefficients exhibited similar directions, magnitudes, and levels of significance compared to our benchmark regression results [Table 5, columns (5–7)].

Additionally, we decomposed the digital economy index back into three dimension variables: digital economy infrastructure, digital industrialisation, and industrial digitisation. These decomposed dimensions were then used as the core explanatory variables in the regressions [Table 5, columns (8–10)]. While confirming that these regression outcomes aligned largely with the conclusions drawn from the baseline regression, it is notable that digital economy infrastructure exhibited the highest potential risk to rural household resilience. This might be linked to energy and environmental issues arising from the construction of digital economy infrastructure, which sometimes leads to increased power consumption. Moreover, as the digital economy embeds into rural areas and households, its integration with traditional rural society may involve a prolonged period of conflict and adaptation. The negative correlation of industrial digitisation, surpassing that of digital industrialisation, indicates China's rapid transformation in digital industrialisation while lagging in industrial digitisation. This underscores the need to further promote the integration of digital technology with agricultural economics, allowing the benefits of the digital dividend to reach ordinary people.

Finally, in investigating the impact of the digital economy on rural household resilience, endogeneity issues related to the core explanatory variable, the digital economy index, were considered. To address this, we proposed three instrumental variable strategies:

First, imitating the approach of Nunn and Qian (2014), we created an interaction term between the 1984 postal service volume (related to individual changes) and the previous year's national software business investment (related to time) for each province

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Table 5. Robustness test results

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)		
											Exogenous test	First stage	Second stage
Digital economy index	–0.0242** (0.0116)	–0.0340** (0.0134)	–0.0316** (0.0129)	–0.0269*** (0.0041)	–0.0318** (0.0128)	–0.0321** (0.0129)	–0.0320** (0.0130)	–	–	–	–	–	–0.1283*** (0.0020)
Digital economy infrastructure	–	–	–	–	–	–	–	–0.2238*** (0.0557)	–	–	–	–	–
Digital industrialization	–	–	–	–	–	–	–	–	–0.0030 (0.0159)	–	–	–	–
Industrial digitization	–	–	–	–	–	–	–	–	–	–0.0756*** (0.0201)	–	–	–
IV_1	–	–	–	–	–	–	–	–	–	–	0.0127 (0.0079)	0.00003*** (0.0000)	–
IV_2	–	–	–	–	–	–	–	–	–	–	0.00006 (0.0000)	0.0008*** (0.0001)	–
IV_3	–	–	–	–	–	–	–	–	–	–	0.0020 (0.0013)	0.0007*** (0.0001)	–
Control variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Province fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Province × year fixed effect	no	yes	no	no	no	no	no	no	no	no	no	no	no
Cragg-Donald statistic	–	–	–	–	–	–	–	–	–	–	–	3 143.779	
R^2	0.1959	0.1434	0.1435	0.1185	0.1435	0.1435	0.1435	0.1439	0.1430	0.1436	–	0.0567	
Observations	10 722	10 722	10 714	10 722	10 722	10 722	10 722	10 722	10 722	10 722		10 722	

*, **, *** significance at the 10%, 5%, and 1% levels, respectively; standard errors in parentheses; to save space, the authors combine the estimated coefficients of the exogeneity test for instrumental variables, but R^2 is not shown in the table because its value can not be combined; (1) Double-sided tail shrinkage treatment; (2) Control interaction fixed effect; (3) Exclude municipalities; (4) Exclude relatively stable indicators; (5) Entropy weight-TOPSIS method; (6) Principal component analysis; (7) Two-step factor method; (8) Digital economy infrastructure; (9) Digital industrialization; (10) Industrial digitization; (11) Instrumental variable

Source: Authors' own processing

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as the first instrumental variable (IV_1) for the digital economy index. The reason for selecting IV_1 is that, from the perspective of correlation, the application of Internet technology originated from the widespread adoption of telephones. Hence, the development of the digital economy also stemmed from the proliferation of fixed-line telephones. In other words, regions with a higher penetration rate of fixed-line telephones are highly likely to be areas with better development of the digital economy. Additionally, postal services are the executing agencies for laying fixed-line telephones, which could also influence the development of the digital economy. From an exogeneity perspective, Goldsmith-Pinkham et al. (2020) refer to this type of instrumental variable as 'shift-share' and argue that the exogeneity of such instrumental variable is primarily determined by the 'share' component. In IV_1, the 'share' corresponded to the 1984 postal service volume, which historically had little impact on macroeconomic growth today.

Second, inspired by Chen and Xu (2023), we used Python software to tokenise government work reports, tallying the frequency of keywords related to the digital economy in provincial government work reports to form a 'digital economy policy keyword frequency' as the second instrumental variable (IV_2) for the digital economy index. It was justified by the fact that a higher proportion of these keywords in government work reports indicated a greater emphasis on digital economy development by local governments. This correlation was evident. Utilising provincial-level government digital economy policy keyword frequency data effectively satisfied the exogeneity assumption between instrumental variables and rural household resilience: the accumulation and change of rural household resilience persist throughout the year, while government work reports are typically formulated at the beginning of the year. The discrepancy in timing between the two effectively mitigates endogeneity issues. Therefore, digital economy policy keyword frequency in this study served as a feasible instrumental variable. Although IV_2 was unrelated to rural household resilience, it still could have been correlated with the error term (unobserved regional development). To eliminate this potential confounding factor, we simultaneously controlled for the real GDP at the provincial level (using 2010 as the base year) in subsequent exogeneity test.

Third, following the practice of Cao et al. (2021), we selected the courier stations in the Ming Dynasty provided by Worldmap of the Center for Geographic Analysis of Harvard University as the third instrumental variable of the digital economy index (IV_3). On the one hand, the courier station in the Ming Dynasty of China was a place to provide accommodation and change horses for postmen or officials who passed on official documents, military information, urgent reports, and so on. In the ancient times, the main task of courier stations was to convey political, military, and economic information, which was equivalent to the ancient logistics centre and postal system. As the ancient national post transportation systems, the Ming Dynasty courier stations have a certain correlation with the modern communication infrastructure. The regions with historical courier stations are more likely to have better information conditions, more developed logistics, and better digital economic development. Consequently, there was a correlation between the location of courier stations in the Ming Dynasty and the digital economy index, which satisfied the correlation condition of the instrumental variable method. On the other hand, since the courier stations in the Ming Dynasty existed before the concept of resilience, this variable did not directly affect rural household resilience and satisfy the exogenous condition of the IV method.

To empirically ensure the exogeneity of instrumental variables before conducting the IV regression, we adopted the following testing approach: if instrumental variables solely affect rural household resilience through endogenous variables (digital economy index), then, when controlling for endogenous and other control variables, instrumental variables should not have a significant impact on rural household resilience. Therefore, we simultaneously included instrumental variables and explanatory variables in the empirical model for regression analysis. The results indicated that the coefficients of the aforementioned three instrumental variables were not significant, suggesting that the selection of instrumental variables met the requirement of exogeneity and possessed a certain level of validity.

The 2SLS regression results are presented in Table 5, column (11). The first-stage regression demonstrated a strong correlation between both instrumental variables and the core explanatory variable (IV_1 is 0.00003, IV_2 is 0.0008, and IV_3 is 0.0007; all were significant at the 1% level), fulfilling the instrumental variable relevance assumption. The weak instrumental variable test statistic (Cragg-Donald statistic) was 3 143.779, far exceeding the Stock-Yogo weak identification test critical value of 13.91 for a 5% bias threshold, indicating the absence of a weak instrumental variable issue. The second-stage regression results closely mirrored the benchmark

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model, indicating that endogeneity concerns do not affect the conclusions of the benchmark model.

Heterogeneity analysis. The Russian economist A.V. Chayanov was the first to analyse peasant household behaviour in the 1920s. He pointed out that the main factor influencing the balance between avoiding labour and generating income for peasants is the household size and the ratio of labour to non-labour members within the household, known as the c / w ratio. This assumption aligns with the current underdeveloped state of local labour markets in rural China. Building upon the Chayanov model, this study constructed interaction terms between the digital economy index and household size, as well as household population structure, to explore how the impact of the digital economy on household resilience differed across households with varying size and population structure characteristics. Regression results are shown in columns (1) and (2) of Table 6. The coefficient of the interaction term between the digital economy index and household size was significantly positive, indicating that larger household sizes experienced a stronger adverse effect of the digital economy on household resilience. Larger rural households often have relatively lower labour force ratios and face higher costs and burdens associated with caring for the elderly and raising children, leading to higher expenditures on education and healthcare (Kuznets 1978). The burden of caring for family members constrains the ability of breadwinners to seek employment opportunities outside their hometowns (Chang and Mishra 2008). Additionally, the high cost of caring for relocated children or elderly relatives increases the instability of resilience alleviation efforts among migrant worker families in urban areas (Nguyen et al. 2017). The coefficient of the interaction term between the digital economy index and household population structure was not significant, suggesting that different household population structures did not lead to significant variations in the influence of the digital economy on household resilience. This result aligns with the findings of several existing studies (Kraay 2000; Wilson 2000; Ramajo et al. 2006)

Table 6. Heterogeneity analysis results

Variable	(1)	(2)	(3)
Digital economy index	–0.0387*** (0.0135)	–0.0346** (0.0138)	–0.0977*** (0.0199)
Digital economy index × household size	0.0011* (0.0006)	–	–
Digital economy index × household population structure	–	–0.0012 (0.0037)	–
Digital economy index × housing property rights	–	–	0.0217*** (0.0064)
Control variables	yes	yes	yes
Province fixed effect	yes	yes	yes
Year fixed effect	yes	yes	yes
R^2	0.1436	0.1449	0.1854
Observations	10 722	10 441	7 236

*, **, *** significance at the 10%, 5%, and 1% levels, respectively; standard errors in parentheses.

Source: Authors' own processing

Rural housing serves as a symbol reflecting local economic development and the prosperity of rural residents. Could the differences in housing property rights attributes lead to variations in the impact of the digital economy on rural household resilience? To explore this question, this study constructed an interaction term between the digital economy index and housing property rights attributes. The regression results are presented in Table 6, column (3). The coefficient of the interaction term between the digital economy index and housing property rights attributes was significantly positive. This result suggests that the adverse impact of the digital economy on household resilience was more pronounced for households living in co-owned or rental properties compared to those residing in self-owned houses. In other words, rural households with more comprehensive control over their housing property rights appeared to navigate the digital economy era more adeptly, with a lower likelihood of their resilience being compromised. This is because the strengthening of housing property rights enables property owners to attain higher transaction values (Musole 2009; Khantachavana et al. 2013), thereby safeguarding their economic interests (Barzel 1997). On the one hand, it provides residential security for rural households (Payne 2004), thereby upholding the welfare function of the housing property rights system (Bengtsson 2001). On the other hand, it enhances the expectations of property monetisation (Wang and Zhang 2017), strengthens rural households' pursuit of potential benefits, and offers robust property rights protection for diversifying the use of homesteads (Yagi and Garrod 2018).

Mechanism analysis. The subsequent sections of this study endeavour to deconstruct the mechanisms through which the impact of the digital economy on rural household resilience operated, focusing on the integrated effects of employment, income structure, and member safeguarding.

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This study constructs 'employment elasticity' as a mechanism variable reflecting the comprehensive effects of employment. The formula for calculating employment elasticity in relation to digitally driven industries is as follows:

$$\varepsilon = \frac{\frac{\Delta N}{N}}{\frac{\Delta G}{G}} \quad (3)$$

where: ε – employment elasticity of digitally driven industries; N – number of employments generated by digitally driven industries; G – output value created by digitally driven industries.

The requisite data for computation is sourced from the National Bureau of Statistics of China (2012–2018).

Column (1) of Table 7 presents the benchmark regression results, consistent with the findings of column (2) in Table 4. By examining the regression outcomes of the digitisation index on the employment elasticity of digital-related industries and the proportion of non-agricultural income in columns (2) and (4) of Table 7, it is evident that the coefficient of the digitisation index was significantly positive at the 1% significance level. This indicates that the advancement of the digital economy contributed to a certain extent to the enhancement of employment elasticity in its related industries and the increase in the proportion of non-agricultural income among rural households. Hence, the corroborative pathway of the digital economy influencing employment elasticity and the proportion of non-agricultural income was substantiated. Furthermore, upon incorporating the employment elasticity mechanism and the non-agricultural income proportion mechanism variables into the baseline model, the absolute value of the coefficient of the digitisation index in columns (3) and (5) of Table 7 experienced a noteworthy increase. This implies that both employment elasticity and the non-agricultural income proportion constituted negative mechanisms through which the digital economy impacted rural household resilience. In other words, to a certain extent, these mechanisms restricted the erosion of rural household resilience by the digital economy. In summary, H_2 and H_3 were confirmed.

Then, we proceed to utilise the proportion of full-time employment among females aged 16 to 59 in rural households and the average cost of supporting individuals under 18 years old (excluding 18) and those aged 60 or above (including 60) in rural households as mechanism variables to represent the mechanisms of female employment and care pressure, respectively. The regression outcomes are presented in Table 8. Column (1) of Table 8 presents the benchmark regression results, which align with column (2) of Table 4.

Firstly, column (2) of Table 8 shows the impact of the digitisation index on female employment. The estimated coefficient was significantly negative at the 5% significance level, signifying that the current trajectory of digital economic development is not particularly favourable for women. Rural women still encountered a range of productive and social challenges as they engaged with the forefront of digital technology and

Table 7. Mechanism analysis results: employment comprehensive effect and income structure effect

Variable	(1)	(2)	(3)	(4)	(5)
Digital economy index	–0.0318** (0.0129)	9.3481*** (0.7586)	–0.0342*** (0.0128)	0.1257*** (0.0457)	–0.0322** (0.0134)
Employment elasticity of digitally driven industries	–	–	0.0003*** (0.0001)	–	–
Proportion of non-agricultural income	–	–	–	–	0.0025*** (0.0009)
Control variables	yes	yes	yes	yes	yes
Province fixed effect	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes
R^2	0.1434	0.3589	0.1438	0.1270	0.1490
Observation	10 722	10 722	10 722	10 034	10 034

*, **, *** significance at the 10%, 5%, and 1% levels, respectively; standard errors in parentheses

Source: Authors' own processing

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Table 8. Mechanism analysis results: member security effect

Variable	(1)	(2)	(3)	(4)	(5)
Digital economy index	–0.0318** (0.0129)	–0.1931*** (0.0436)	–0.0310** (0.0139)	–1.6374*** (0.1677)	–0.0340** (0.0145)
Female employment	–	–	0.0022* (0.0013)	–	–
Care pressure	–	–	–	–	0.0002 (0.0002)
Control variables	yes	yes	yes	yes	yes
Province fixed effect	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes
R^2	0.1434	0.1009	0.1389	0.0552	0.1423
Observation	10 722	9 162	9 162	7 986	7 986

*, **, *** significance at the 10%, 5%, and 1% levels, respectively; standard errors in parentheses.
Source: Authors' own processing

entered digital economic sectors. While aspects such as the decreasing entry barriers in digital economic formats like agricultural e-commerce enabled easy access for rural women, the intensifying competition and the increasing demand for sophisticated digital skills presented formidable hurdles. Concurrently, gender barriers targeting rural women have not been fully dissolved, and the traditional division of labour within households, characterised by the 'male breadwinner, female homemaker' model, still exerts influence in the digital economy era. Further insight was gained by incorporating the female employment mechanism variable into the benchmark model. In column (3) of Table 8, the absolute value of the coefficient of the digitisation index experienced a significant decrease. This implies that the enhancement of female employment levels constituted a negative mechanism through which the digital economy influenced rural household resilience. To be specific, the dual propulsion of female employment probability and stability served to foster an enhancement in rural household resilience.

Secondly, as shown in column (4) of Table 8, the impact of the digitisation index on care pressure was explored. The estimated coefficient was significantly negative at the 1% significance level, indicating that the digital economy significantly reduced the cost of care for rural households. This highlights the remarkable advantages of the digital economy in terms of convenience and cost-effectiveness. It not only alleviated the pressures of daily life but also substantially improved the overall quality of life. By adding the care pressure mechanism variable to the benchmark model, column (5) of Table 8 reveals that the absolute value of the coefficient of the digitisation index saw a significant increase. This suggests that care pressure constituted a negative mechanism through which the digital economy influenced rural household resilience. To clarify, a certain degree of elevated care costs posed a hindrance to the development of rural household resilience. In conclusion, H_4 was confirmed.

CONCLUSION

This study was founded upon microdata from the CLDS for 2012, 2014, 2016, and 2018. To the best of our knowledge, this is the first paper that systematically computed the rural household resilience index in China. Building upon the index, this study investigated the impact of the digital economy on rural household resilience and dissected the group disparities as well as underlying mechanisms between them. The primary findings of this research are as follows: from 2012 to 2018, the Chinese rural household resilience index had significant differences in time and space, and village market, gentry assistance, economic organisation, and income from collective operation were the most important indicators affecting the rural household resilience index. To some extent, the improvement of the digital economy index suppressed the improvement of the rural household resilience index. Meanwhile, heterogeneity analysis suggested that depending on family size and housing property rights, the impact of the digital economy on the resilience of rural households will be divided. Moreover, mecha-

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nism analysis showed that the digital economy further affected the resilience of rural households through the employment comprehensive effect, income structure effect and member security effect.

Taking into account the aforementioned research findings, the following policy insights were derived. Firstly, seize the opportunities of the digital economy development era to elevate agricultural digitisation levels and fortify rural household resilience. Secondly, promote the development of the digital economy in a targeted and context-specific manner, formulate tailored strategies, and remain cautious of the potential for the digital economy to undermine rural household resilience. Thirdly, innovate talent systems and mechanisms, unleashing innovation vitality and encouraging talented individuals to return to rural areas. Fourthly, propel high-quality development of agricultural insurance, formulate targeted policies, and enhance rural household resilience capacity. Finally, advance the reform of rural homestead property rights in conjunction with industrialisation, urbanisation, and digitalisation effectively, so as to construct a homestead property rights system characterised by clear ownership, orderly transfer, and alignment with the needs of economic and social development.

Some limitations of this study remain. First, the availability of CLDS data prevents us from constructing a digital economy index at the household or village level. Consequently, we are compelled to construct the digital economy index at the provincial level. The lack of long-term panel data also makes it challenging to identify the nonlinear change characteristics of how the digital economy affects rural household resilience. We hope to address this in future research by exploring alternative micro-level datasets or conducting fieldwork to gather relevant data. Second, the construction of any index system, indeed, is not without its challenges. In the digital economy and rural household resilience index system that we have constructed, there are still some indicators that require further refinement, modification, and enhancement to better align with theory and reality. Third, in this paper, we only explored the heterogeneity of the impact of the digital economy on rural household resilience from three perspectives: family size, population structure, and housing property rights. Simultaneously, we only elucidated the mechanism channels through the employment comprehensive effect, income structure effect and member security effect. However, there are still many potential heterogeneities and mechanisms awaiting further exploration.

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