Digital Economy and Rural Household Resilience: Evidence from China

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Abstract

Strengthening the ability of peasant households to resist the impact of risks and shaping their "small but strong" resilience is of great practical significance for maintaining and consolidating the achievements of poverty alleviation, narrowing the gap between urban and rural areas, and promoting the realization of common prosperity. Taking "how digital economy changes the rural household resilience " and the micro data of China Labor-force Dynamics Survey (CLDS), this paper systematically measures the rural household resilience index for the first time, analyzes the impact of digital economy on the resilience of rural household, and dissects the group differences and mechanism of action. The study found that: (1) from 2012 to 2018, the Chinese rural household resilience index had significant differences in time and space, and village market, gentry assistance, economic organization, income from collective operation were the most important indicators affecting the rural household resilience index. (2) The improvement of the digital economy index has to some extent suppressed the improvement of the rural household resilience index, and this conclusion is still true after a series of robustness tests. (3) Heterogeneity analysis found that depending on family size and housing property rights, the impact of the digital economy on the resilience of rural households will be divided. (4) Mechanism analysis showed that the digital economy further affects the resilience of rural households through the employment comprehensive effect, income structure effect and member security effect. This paper indicates that the rational use of digital economy, improving the level of agricultural digitalization, enhancing the resilience of rural households, and vigilance against the weakening of resilience by the externalities of digital economy are the realistic ways of forging "resilient small farmers" and realizing common prosperity.

Key words: Digital Economy; Rural Household Resilience; Random Forest Algorithm; Index System; CLDS
JEL Classification: Q12, O33, D13

1 Introduction

The fundamental reality of China's agriculture and rural situation is an unavoidable premise when discussing the issues concerning the country's agriculture, countryside, and farmers (The "Three Rural" Issues). The predominant form of agricultural operations in China is characterized by small-scale family-based farming. The dispersed operating model of "one family, one household" is an enduring reality that China's agricultural modernization process must confront in the long term. Historical experience also demonstrates that the small-scale economic foundation built by countless small farming households has laid the profound cultural heritage of Chinese civilization, continuing for thousands of years without interruption. However, from the perspective of modern mainstream economics, agriculture is considered a weak sector, displaying evident fragility when facing risk shocks [1]. The inherent vulnerability that small farming households face in coping with risks leads to their characterization as "fragile farmers". Moreover, the long-standing dual urban-rural system and the policy bias towards urban areas have distorted the urban-rural relationship, seemingly entrenching the existence of the "fragile farmers" as an economic form. Consequently, the vulnerability and resilience of China's small farming households unfold as a contradictory pair within the complex historical dimension and practical context. In 2020, China achieved the goal of eradicating absolute poverty in rural areas, securing a comprehensive victory in the fight against

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poverty. As a result, the focus of "three rural" work underwent a historic shift. However, it is worth being 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 [2]. 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 with the objective of objectively assessing rural household resilience to uncertainty shocks. This system aims to measure the true level of resilience among households in various provinces and explore ways to enhance their capacity to withstand risk shocks. These efforts are crucial for preserving and consolidating the results of poverty alleviation, narrowing the urban-rural gap, and promoting common prosperity.

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 [3-7], agricultural resilience [8-12], and poverty alleviation [13-20]. Among them, scholars have described rural household resilience as the opposite of vulnerability for small farming households. It refers to the characteristic of 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 [21]. For instance, Milhorance et al. [22] defined rural household resilience as the ability to resist significant emergencies, representing the level of psychological capital among rural households. Meanwhile, Gupta et al. [23] analyzed the cases of poverty alleviation and livelihood transformation in 16 villages in the Himalayas of India and Nepal, and point out that the resilience of small farmers is manifested through their behavior, reflecting a specific political and socio-economic state constructed through interactions with the state and society. 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. Su et al. [24] used a weighted TOPSIS method to measure the rural resilience of 153 research units from 2000 to 2019 and then applied the ESDA method to measure the spatial agglomeration or heterogeneity characteristics. Zhou et al. [25], on the other hand, developed the "Pressure-State-Response" (PSR) model based on practical investigations to assess the economic resilience of rural areas in both traditional agricultural regions and impoverished areas. Additionally, Farahani et al. [26] directly investigated the issue of rural household resilience. They further subdivided rural household resilience from the perspective of resilience capacity into economical resilience, social resilience, psychological resilience, physical resilience, institutional resilience and environmental resilience. Moreover, they outlined the specific components of each resilience category, providing ideas for quantitatively measuring rural household resilience. Thirdly, the influencing factors of rural household resilience. Against the backdrop of common prosperity and rural revitalization, 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. For instance, Cox et al. [27] described the development and field testing of the Rural Resilience Index (RRI), an applied disaster resilience assessment index for use in rural and remote communities. The RRI emphasized the value of citizen engagement in resilience planning and a whole-of-community approach to resilience addressing issues such as the quality

and availability of local resources, economic issues and emergency management. Liu et al. [28] explored the logical framework and mechanism of agricultural integration on agricultural resilience from the perspective of agricultural vulnerability. They examined the interactions between value chains and rural communities in a rapidly developing city-region of Wuhan, China. Findings of their study suggested the importance of linking rural community development with agri-food value chain development, with a view to build rural resilience alongside agri-food value chain development. Furthermore, Cutter et al. [29] focused solely on economic resilience and, based on poverty traps and nonlinear dynamics theories, dynamically measure rural household economic resilience. They then investigated the impact of the development level of agricultural insurance on rural household economic resilience from the perspective of household heterogeneity.

From this perspective, systematically exploring the key factors that affect rural household resilience and analyzing their mechanisms is crucial for accelerating rural revitalization and promoting the modernization of agriculture and rural areas in China, which is based on small-scale farming. 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 [30], based on using Location Quotient (LQ) analysis as an analysis tool to identify leading sectors in each region throughout Indonesia, analyzed the effects and mechanisms of the digital economy on agricultural economic resilience. It was pointed out that the digital economy significantly promotes the enhancement of agricultural economic resilience and has positive spatial spillover effects. Almunawar et al. [31] confirmed this viewpoint, stating that the digital economy increases the supply and demand of high-quality talents, spreads positive externalities and learning effects of human capital, thereby empowering agricultural resilience. 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 the role of the digital economy in shaping rural household resilience remains an unclearly expressed and relatively less explored real-world issue that aligns with the characteristics of the new era. In light of this, this paper takes "how the digital economy changes rural household resilience" as the starting point and, based on China Labor-force Dynamics Survey (CLDS) microdata, systematically calculates the rural household resilience index for the first time. It empirically analyzes the impact of the digital economy on rural household resilience and examines group differences and mechanisms at play.

2 Theoretical analysis and research hypothesis

2.1 The direct impact mechanism of digital economy on rural household resilience

The concept of "digital economy" was first proposed by Tapscott in 1996 [32]. As information technology has matured and the level of digitalization in the economy and society has continuously improved, the scope and connotation of the "digital economy" have expanded further. In 2016, the G20 Digital Economy Development and Cooperation Initiative defined the digital economy as "a series of economic activities that use digitized knowledge and information as key production factors, modern information networks as important carriers, and the effective use of information and communication technology as a significant driving force for efficiency improvement and economic structural optimization"[33]. Bukht et al. [34] divided the digital economy into three main layers:

the core layer, the narrow layer, and the broad layer. Rong [35] believed that the digital economy should be supported by infrastructure construction as the "ballast stone", with the development of digital industries as the foundation and the deep integration of industrial digitalization as the focus. They emphasize the continuous expansion of the breadth and depth of the digital economy through a well-guaranteed digital economic environment, including governance and innovation environments.。

Given that farmers traditionally tend to be conservative and reluctant to accept new things, they often face unpreparedness when confronted with technological revolution such as the digital economy. This lack of preparedness can easily lead to difficulties and expose their vulnerability. In reality, Chinese small farming households are not an inherently "fragile and short-lived" economic form but rather a resilient and enduring production entity. 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, the "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 [21]. Therefore, this paper proposes Hypothesis 1:

Hypothesis 1 The digital economy has a significant impact on the resilience of rural household.

2.2 The indirect transmission mechanism of digital economy affecting rural household resilience

The digital economy is profoundly impacting the transformation of the job market, leading to a metamorphosis in job carriers, job forms, and job skill requirements. This phenomenon brings both significant opportunities for job creation and significant challenges due to job displacement [36]. The creation effect means that the digital economy will generate a large number of new types of job positions, such as software development and chip design fields. The integration of the digital economy and inclusive finance also enhances workers' confidence and probability of entrepreneurship [37-38]. On the other hand, the substitution effect implies that some repetitive jobs that can be encoded are facing a trend of replacement, and certain low-end job positions may gradually be substituted by technology in the rapid development of the digital economy. The unity of the creation and substitution effects represents the comprehensive impact of the digital economy on employment. Whether the digital economy expands or reduces employment cannot be generalized, but it fundamentally transforms the job market and will inevitably further influence the resilience of rural households. Therefore, Hypothesis 2 is proposed:

Hypothesis 2 The digital economy has a significant impact on rural household resilience through its comprehensive effect on employment.

Income structure exhibits a typical "long-tail" feature, with the majority of wealth concentrated in a few individuals at the top of the income pyramid, while the bottom of the income structure includes the majority of people with extremely limited wealth, forming a pyramid-shaped distribution. In a traditional non-digitalized society, rural households have limited access to non-agricultural work, making it challenging for non-agricultural income to serve as a means to improve overall income. The digital economy has changed the traditional characteristics of access for tail-end farmers, eliminating the isolation between "long-tail" farmers and the non-agricultural job market. It has become an essential means to improve the income structure of rural households [39]. Since 2017, with the deepening implementation of the rural revitalization strategy, as of the end of 2021, the per capita disposable income of rural residents has increased by 40.93%. Among them, wage income has increased by 44.73%, net operating income has increased by 30.60%, net property income has increased by 54.92%, net transfer income has increased by 51.24%, and non-agricultural

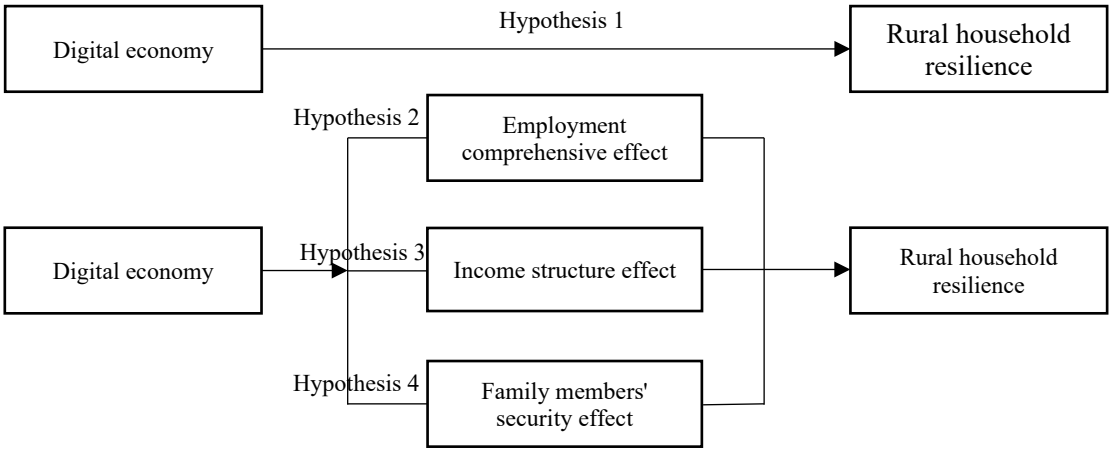
income has increased by 45.79%. In 2021, non-agricultural income accounted for 77.3% of the per capita disposable income of rural residents, becoming the main source of income for farmers[1]. The diversity of income sources for rural households facilitates their ability to respond to external shocks, reduces family risks through preventive measures, smoothes income fluctuations, and enhances economic security, thereby strengthening household resilience [40]. Therefore, Hypothesis 3 is proposed:

Hypothesis 3 The digital economy has a significant impact on rural household resilience through its effect on income structure.

With the further acceleration of China's urbanization process, a large number of rural laborers are flowing into cities. The outflow of rural labor has a positive impact on rural development, playing an important role in increasing farmers' income and promoting the transfer of labor from the primary industry to other industries. However, during the massive outflow of rural labor, a new social phenomenon has become increasingly prominent, known as the "386199" phenomenon. These numbers represent different groups: "38" represents women, "61" represents children, and "99" represents the elderly. This set of numbers symbolizes the fact that due to the outflow of male-dominated young and middle-aged labor, the remaining family members in rural areas are mainly composed of women, children, and the elderly, and such families are referred to as "left-behind households." Families are the basic units of society, and rural households commonly bear multiple functions such as agricultural production, child education, and elderly support [41-45]. The digital economy may impact the family roles of "left-behind women" and the child-rearing costs of "left-behind children" and "left-behind elderly" and have implications for the resilience of left-behind households. Previous studies have shown that under the drive of "Internet Plus", the digital economy has a more significant effect on increasing income for rural families compared to urban families, indicating that digital technology offers development opportunities for vulnerable farmers, which helps to narrow the poverty gap [46]. The thriving development of agricultural product e-commerce has also provided new opportunities for rural women engaged in agricultural production, enabling them to achieve employment and increased income [47-49]. Moreover, in the information age, digital technology is subtly changing the consumption concepts and patterns of children and the elderly, unlocking their consumption potential [50-51]. Therefore, Hypothesis 4 is proposed:

Hypothesis 4 The digital economy has a significant impact on rural household resilience through its effect on family members' security.

Based on the above analysis, the theoretical analysis framework constructed in this paper is shown in Figure 1:



[1] Data are based on the *"China Rural Statistical Yearbook"*.

Figure 1. Theoretical analysis framework

3 Study design

3.1 Variable measures

3.1.1 Measurement of the digital economy index

The core explanatory variable in this study is the Digital Economy Index. Building upon the essence of the digital economy, this paper delves into the prerequisites, applications, and milieu of the digital economy. Drawing insights from the approaches proposed by scholars such as Mesenbourg [52], Bukht et al. [34], Barefoot et al. [53] and Ma et al. [54], a comprehensive assessment methodology was formulated. The endeavor entailed selecting 30 indicators across three dimensions—namely, digital economic infrastructure, digital industrialization, and industrial digitization—as elucidated in Table 1. To expound further: the dimension of digital economic infrastructure encompasses traditional infrastructure, novel digital infrastructure, and rural digital infrastructure, with a comprehensive breakdown of 10 sub-indicators; the dimension of digital industrialization (expansion of digital industry) encapsulates industrial revenue, industrial scale, and industrial innovation, manifested through a multi-tiered composition of 10 sub-indicators; and finally, the dimension of industrial digitization (digital transformation of traditional industries) encompasses agricultural digitization, industrial digitization, and service industry digitization, underpinned by 10 sub-indicators across three tiers.

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	+
Industrial digitalization	Digitalization of agriculture	Number of technical contract registration	+
		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	The 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	+

3.1.2 Measurement of rural household resilience index

Grounded in the five characteristics of "resilient farmers" - adaptability, stability, absorptivity, flexibility, and assistance - this study selects 20 indicators (Table 2) to measure the level of rural household resilience based on principles of scientific rigor, hierarchy, and attainability. Specifically, adaptability refers to the ability of households to survive in changing external environments, encompassing indicators such as land area, part-time income, village topography, and village greenery. Stability denotes the capacity of households to maintain their existence and continuity under external pressures, incorporating indicators like agricultural labor force size, family relationship, collective income, and clan size. Flexibility signifies the ability of households to take appropriate measures in complex and changing circumstances, encompassing indicators related to cropping pattern, expenditure pattern, economic organization, and information dissemination. Absorptivity refers to households' capability to secure survival and continuity through external energy absorption, covering indicators such as internet usage, electricity availability, farm machinery quantity, and rural markets. Lastly, assistance reflects the capacity of households to seek external aid for survival and continuity during times of adversity, involving indicators like blood-related assistance, gentry assistance, villager mutual assistance, and government assistance.

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	y1	Number of acres of household land	+
	Part-time income	y2	Total household wage income	+
	Village topography	y3	Village topography	-
	Village greenery	y4	Village green coverage	+
Stability characteristics	Agricultural labor force size	y5	Number of households engaged in agricultural production	+
	Family relationship	y6	Relationships between family members	+
	Collective income	y7	Village collective financial revenue	+
	Clan size	y8	Proportion of the largest surname in village population	+
Flexibility characteristics	Cropping pattern	y9	Family land farming type	+
	Expenditure pattern	y10	Family Engel coefficient	-
	Economic organization	y11	Types of village economic organizations	+
	Information dissemination	y12	The main way for village committees to disseminate information to villagers	+
Absorptive characteristics	Internet usage	y13	The cost of the Internet spent by the family using the computer	+
	Electricity availability	y14	Electricity in the home	+
	Farm machinery quantity	y15	Number of household tractors and large farm implements	+
	Rural markets	y16	Types of village markets	+
Assistance characteristics	Blood-related assistance	y17	Remittance income from family relatives	+
	Gentry assistance	y18	The amount of donations to the village by people who have traveled from the village	+
	Villager mutual assistance	y19	The degree of harmony between villagers	+

Government assistance	y20	Proportion of hardened pavement in village	+	

3.1.3 Explanation of controlled variables

To control for the influence of other characteristic variables of rural households and their respective villages on their resilience, this study sets the following control variables: (1) Household characteristics:①Household economic status;②Household environmental condition; ③Household pensions or retirement fund; ④Household debts; ⑤Household education expenditures. (2) Village characteristics: ⑥Total administrative area of the village; ⑦Neatness of the village appearance; ⑧Number of village enterprises; ⑨Location conditions of the village (measured by the distance to the nearest county/city government); ⑩Village security conditions.

3.2 Data source

The construction of the digital economy index in this paper is based on macro-level indicators at the provincial level. The data primarily originates from the *"China Statistical Yearbook", "China Meteorological Yearbook", "China Information Yearbook", "China Electronic Information Industry Statistical Yearbook", "China Science and Technology Statistical Yearbook", "China Torch Statistical Yearbook", "China Information Industry Yearbook", "China Internet Development Report by Wangsu", "China E-commerce Report", "White Paper on E-commerce of Agricultural Products (2012)", "Research Report on China's Taobao Villages (2009-2019)"* and *"Peking University's Digital Inclusive Finance Index Report"*. The rural household resilience index is constructed using micro-level indicators at the household level. The data mainly comes from the *China Labor-force Dynamics Survey (CLDS)* for the years 2012, 2014, 2016, and 2018. This paper retains household samples from the CLDS data that have rural agricultural household registration and matches them with corresponding village data, resulting in a mixed cross-section data covering 10722[2]households in rural areas. Additionally, interpolation has been applied to supplement missing data. Descriptive statistical results of the variables are presented in Table 3.

Table 3 Descriptive statistics of the variables

Variable name	Variable description	Observations	Mean	Standard deviation	Minimum	Maximum
Rural household resilience index	Calculated by the entropy method	10722	0.0708	0.0401	0.0133	0.3819
Digital economy index	Calculated by the entropy method	10722	0.1384	0.1434	0.0105	0.6616
Household economic status	An ordered integer of 1~10, representing from poor to rich	10722	5.2916	1.7565	1	10
Household environmental condition	An ordered integer of 1~10, representing from dirty to tidy	10722	5.8798	1.7820	1	10
Household pensions or retirement fund	Family divorce or retirement income in 2017, plus 1 to take the natural logarithm	10722	0.4558	1.9224	0	12.2259
Household debts	The total amount of money owed (borrowed) by the household, plus 1 to take the natural logarithm	10722	3.5327	4.8487	0	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	10722	4.1359	4.2476	0	12.2061
Total administrative area of the village	The total administrative area of the village, taken as the natural logarithm	10722	1.5427	1.3972	-5.8091	6.6846

[2] The specific sample size may vary in subsequent studies as control variables are removed, heterogeneous variables are introduced, and mechanism variables are included.

Neatness of the village appearance	An ordered integer of 1~10, representing from dirty to tidy	10722	7.1180	1.6954	1	10
Number of village enterprises	The number of enterprises (excluding shops and supermarkets) in the administrative area of the village, plus 1 to take the natural logarithm	10722	0.5476	0.9501	0	5.7071
Location conditions of the village	The distance from the nearest county or district government to the village, plus 1 to take the natural logarithm	10722	3.0110	0.8488	0	5.7071
Village security conditions	1=Very good, 2=Good, 3=Fair, 4=Not Good, 5=Poor	10722	4.3604	0.6757	1	5

3.3 Research methods

3.3.1 Entropy method

In the process of calculating the Digital Economy Index and Rural Household Resilience Index, to avoid the inaccuracy caused by subjective weighting, this study employs the entropy weighting method within the objective weighting approach to assign weights to the indicators. The steps of the entropy weighting method are as follows:

Step One, standardization:

$$\text{Positive indicators: } x'_{ij} = \frac{x_{ij} - min\{x_j\}}{max\{x_j\} - min\{x_j\}} \quad (1)$$

$$\text{Negative indicators: } x'_{ij} = \frac{max\{x_j\} - x_{ij}}{max\{x_j\} - min\{x_j\}} \quad (2)$$

Where x_{ij} represents the value of the *j*-th indicator in the *i*-th, x'_{ij} denotes the standardized result, $max\{x_j\}$ stands for the maximum value of the indicator x_{ij}, and $min\{x_j\}$ refers to the minimum value of the indicator x_{ij}.

Secondly, calculate the weight of each indicator w_{ij}:

$$w_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x'_{ij}} \quad (3)$$

Where *m* represents the number of covered years.

The third step is calculating the entropy of each indicator e_j:

$$e_j = -\frac{1}{lnm} \sum_{i=1}^{m} w_{ij} \times lnw_{ij} \quad (4)$$

The fourth step is calculating the redundancy of the entropy d_j:

$$d_j = 1 - e_j \quad (5)$$

The fifth step is calculating the weights of the indicators h_j:

$$h_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad (6)$$

The sixth step is calculating the comprehensive index:

$$RHRI_{ij} = \sum_{j=1}^{m} h_j \times w_{ij} \quad (7)$$

In the formula, $RHRI_{ij}$ represents the rural household resilience index[3] of province *i* in year *j*, ranging from 0 to 1. A higher value of $RHRI_{ij}$ indicates a higher level of rural household resilience, and vice versa. The calculation method for the Digital Economic Index (DEI_{ij}) is similar and will not be reiterated.

3.3.2 Random forest algorithm

"Random Forest" is an emerging approach used for prediction through statistical or machine

[3] The provincial rural household resilience index is obtained by calculating the average or median of the resilience scores of all rural households within the same province.

learning algorithms. Considering the nonlinear relationships within data, this method has gained widespread application in the field of social sciences, with promising predictive outcomes, fueled by the advancements in big data technologies. Simultaneously, the ensemble learning algorithm of Random Forest is particularly well-suited for large datasets. Particularly in cases where the number of independent variables exceeds the number of observations, linear regression and logistic regression might fail to operate, yet Random Forest can still effectively perform regression tasks. Consequently, Random Forest stands out as one of the most proficient statistical learning algorithms today. To delve into specifics, a drawback of traditional decision tree algorithms is their tendency to overfit, indicating that the model strictly adheres to features within the training dataset, leading to poor performance on new data (testing data) and consequently lower predictive accuracy, or generalization accuracy. In contrast, the Random Forest algorithm provides more accurate estimates of error rates. During training, the error of Random Forest is approximated by the Out-of-Bag (OOB) error. Leveraging the OOB error, the Random Forest algorithm enables the ranking of variable importance [55]:

In the first step, for each decision tree, the random forest error is approximated using the OOB data, denoted as$rforest_error_1$;

Moving to the second step, random noise is introduced to the feature λ within the OOB data, and once again, an approximation of the Random Forest error is computed, referred to as $rforest\_error_2$;

In the third step, assuming there are N decision trees, the importance of feature λ can be expressed as follows:

$$Importance = \frac{\sum_{i=1}^{N}(rforest_{error2} - rforest_{error1})}{N} \tag{8}$$

3.3.3 Linear regression model

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

$$RHRI_{ijk} = \beta_0 + \beta_1 DEI_{ijk} + \beta X_{ijk} + \gamma_i + \delta_j + \varepsilon_{ijk} \tag{9}$$

In the equation, $RHRI_{ijk}$ represents the resilience index of rural household k located in province i during year j, while DEI_{ijk} signifies the provincial-level digital economy index attained by rural household k in province i during year j. X_{ijk} denotes a set of control variables, γ_i represents province fixed effect, δ_j accounts for year fixed effect, and ε_{ijk} stands for the random disturbance term.

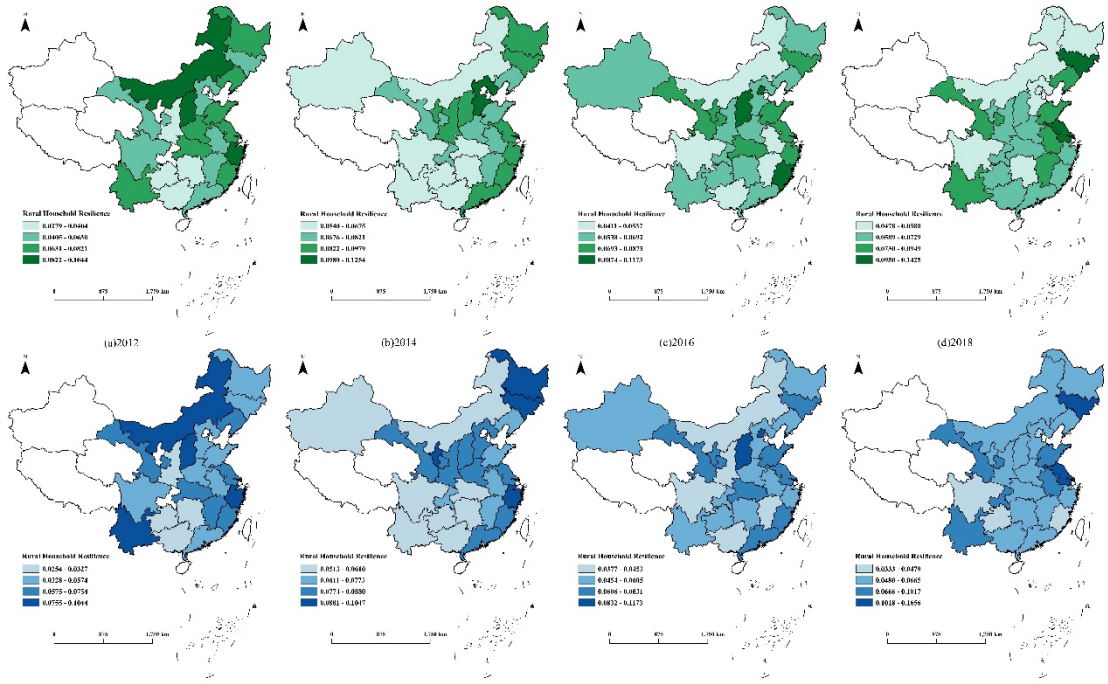
4 Empirical results and analysis

4.1 Analysis of rural household resilience index

Figure 2 depicts the results of the calculated rural household resilience indices for 26 provinces[4] in China for the years 2012, 2014, 2016, and 2018, as determined through the aforementioned entropy weighting method. It is evident that the rural household resilience indices exhibit 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 display 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 have shown enhanced adaptability to

[4] Due to data limitations, the analysis excludes the regions of Tianjin, Shanghai, Hainan, Qinghai, 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.

complex external changes, continuously absorbing beneficial external energy, thus achieving resilience for renewal and continuation. This trend further affirms that the process of rural reform in China entails a continuous enhancement of rural households' resilience capabilities[56]. Regarding spatial distribution, the rural household resilience indices across different regions in China exhibit a clustered distribution pattern. Strongly resilient rural households are predominantly concentrated in the eastern coastal and Yellow River middle and lower reaches regions. In contrast, weaker resilience is more prevalent in the western inland areas. This spatial pattern is partially related to the local natural endowment conditions and economic development levels. It is noteworthy that the $RHRI$ for the Inner Mongolia region experiences a significant decline. This trend can be attributed to the fact that a considerable portion of households in this region consists of herders, leading to a relatively monotonous agricultural production structure. Additionally, the ongoing contraction of the desertification in the Hulunbuir grassland is limiting the space for the survival and development of herders, thus subjecting them to a relatively challenging economic environment.

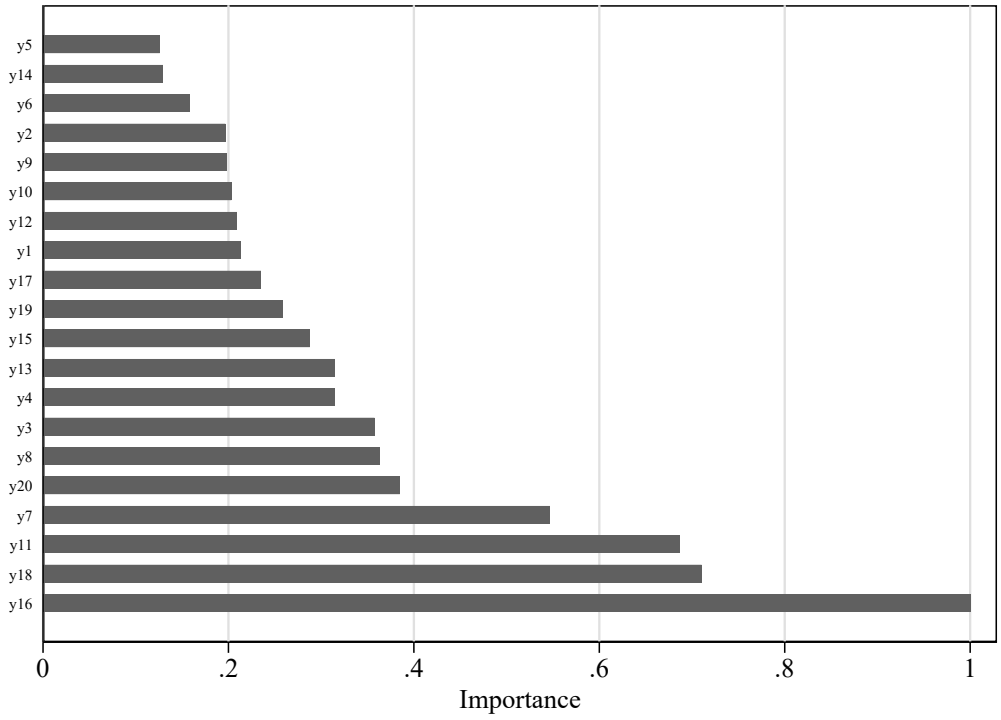


Note: The base map is sourced from the Standard Map Service System (http://bzdt.ch.mnr.gov.cn/) of the Geographic Information and Map Division of the National Administration of Surveying, Mapping and Geoinformation with approval number GS (2020) 4619, and has not been modified. The upper part displays 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 12601 households compared to the mixed cross-sectional data.

Figure 2. Rural household resilience index of 26 provinces in 2012, 2014, 2016 and 2018

Furthermore, this study has utilized the random forest algorithm to identify the significant importance levels of various indicators contributing to the rural household resilience index (as shown in Figure 3. In terms of the ranking of importance, the top four indicators include village market(y16), gentry assistance(y18), economic organization(y11), and income from collective operation(y7), all of which exhibit importance coefficients exceeding 0.5. This underscores that marketization, organization, and collectivization not only enhance the internal capacity of household production but also create unprecedented favorable external environments for development. These aspects constitute feasible pathways to further strengthen and elevate their resilience. Conversely, the three indicators ranked towards the lower end are number of labor in family farming production(y5), power-on condition(y14), and family relationship(y6), all of which hold influence

coefficients below 0.2. On one hand, achieving comprehensive and stable rural electrification coverage, along with endeavors like upgrading rural power grids and implementing unified electricity pricing for urban and rural areas, has mitigated obstacles tied to electricity for rural households. On the other hand, the introduction of capital, technology, and entrepreneurial talents has gradually emancipated rural households from inefficient labor-dependent production models, steering them towards intensive and efficient pathways of modern agricultural development. From this perspective, the realization of an "organic connection between small-scale farmers and modern agricultural development" holds the key to effectively elevating the rural household resilience index.



Note: The sample size is 12,601 households.

Figure 3. Random forest algorithm visualization of the constituent indicator importance in the rural household resilience index

4.2 Benchmark regression analysis

The results of the benchmark regression are presented in Table 4. Column (1) shows the regression results with only household characteristic control variables, while column (2) includes all control variables related to both household and village characteristics. The regression results indicate that the estimated coefficient of the core explanatory variable, the digital economy index, is negative and statistically significant at the 5% level. This implies that a higher level of digital economic development in the region where households are located is associated with a lower level of household resilience. Specifically, taking the results from column (2) as an example, for each 1-unit increase in the digital economy index, the household resilience index is estimated to decrease by approximately 0.03 units. This suggests that the current state of the digital economy does not effectively enhance household resilience, indicating practical challenges in leveraging the digital economy to improve rural livelihoods. In summary, the regression results confirm Hypothesis 1.

Table 4 Benchmark regression results

Variable	(1)	(2)
Digital economy index	-0.0255**	-0.0318**
	(0.0130)	(0.0129)

Household economic status	0.0020***	0.0020***
	(0.0003)	(0.0003)
Household environmental condition	-0.0005*	-0.0007**
	(0.0003)	(0.0003)
Household pensions or retirement fund	0.0003	0.0004
	(0.0002)	(0.0002)
Household debts	0.0002*	0.0002**
	(0.0001)	(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 the 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	0.0494***	0.0316***
	(0.0118)	(0.0119)
Province fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
R^2	0.1176	0.1434
Observation	10722	10722

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors in parentheses. The same notation applies below.

4.3 Robustness test

Given the substantial size of the sample data, and to mitigate the potential impact of outliers on regression outcomes, this study initially conducted a two-tailed trimming of the sample at the 1st and 99th percentiles (Table 5, Column (1)). Similar to the baseline regression results, an increase in the digital economy index was found to lower rural household resilience levels.

Furthermore, recognizing the differences between municipalities directly under central government administration and provincial-level data in terms of administrative hierarchy, economic structure, and taxation methods, this study re-conducted regressions after excluding the four municipalities (Beijing, Tianjin, Shanghai, Chongqing) to test the impact of the digital economy (Table 5, Column (2)). The robustness of these results was consistent with the benchmark regression outcomes.

Additionally, this study decomposed the digital economy index back into three dimension variables: digital economy infrastructure, digital industrialization, and industrial digitization. These decomposed dimensions were then used as core explanatory variables in the regressions (Table 5, Columns (3)–(5)). While confirming that these regression outcomes align largely with the conclusions drawn from the baseline regression, it is notable that digital economy infrastructure exhibits 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 digitization, surpassing that of digital industrialization, indicates China's rapid transformation in digital industrialization while lagging in industrial digitization. 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, the study proposed two instrumental variable strategies. First, it followed the approach of Nunn et al. [57], creating 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 as the first instrumental variable for the digital economy index. Second, inspired by Chen et al. [58], the study used Python software to tokenize 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 for the digital economy index. The 2SLS regression results are presented in Table 5, Column (6). The first-stage regression demonstrated a strong correlation between both instrumental variables and the core explanatory variable, fulfilling the instrumental variable relevance assumption. The weak instrumental variable test statistic (Cragg-Donald statistic) was 5872.952, far exceeding the critical value of 19.93 for a 10% bias threshold, indicating the absence of a weak instrumental variable issue. The second-stage regression results closely mirrored the benchmark model, indicating that endogeneity concerns do not affect the conclusions of the benchmark model.

Table 5 Robustness test results

Variable	(1) Double-sided tail shrinkage treatment	(2) Exclude municipalities	(3) Digital economy infrastructure	(4) Digital industrialization	(5) Industrial digitization	(6) Instrumental Variable
Digital economy index	-0.0383***	-0.0316**				-0.1325***
	(0.0127)	(0.0129)				(0.0178)
Digital economy infrastructure			-0.2238***			
			(0.0557)			
Digital industrialization				-0.0030		
				(0.0159)		
Industrial digitization					-0.0756***	
					(0.0201)	
1984 postal service volume×software business investment						0.00003***
						(0.0000)
Digital economy policy keyword frequency						0.0003***
						(0.0000)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Cragg-Donald statistic						5872.952
R^2	0.1682	0.1435	0.1439	0.1430	0.1436	0.1390
Observation	10722	10714	10722	10722	10722	10722

5 Further analysis

5.1 Heterogeneity analysis

5.1.1 Household size and demographic characteristics

The Russian economist A.V. Chayanov was the first to analyze peasant household behavior in the 1920s. The Chayanov peasant model is based on the theory of household utility maximization, where peasant households have two independent goals: first, an income goal that requires field labor to achieve, and second, an avoidance of labor goal that opposes income attainment. Therefore, the Chayanov theory is also known as the "labor aversion" peasant theory. The main factor influencing the balance between avoiding labor and generating income for peasants is the household size and the ratio of labor to non-labor members within the household, known as the c/w ratio[59]. Additionally, the unique aspect of small-scale farming is a cornerstone of the Chayanov model, which assumes the absence of a labor market. This assumption aligns with the current underdeveloped state of local labor markets in rural China [60]. Building upon the Chayanov model, this study constructs 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 differs 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 is significantly positive, indicating that larger household sizes experience a stronger adverse effect of the digital economy on household resilience. Larger rural households, often consisting of three generations or more, have relatively lower labor 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. Moreover, vulnerable groups such as the elderly and children are more susceptible to illness. The uncertainty brought by the digital economy's impact could potentially reduce per capita income, increasing the risk of poverty for households burdened by such population dynamics [61], making it difficult to maintain stability, continuity, and qualitative improvement of resilience levels. The coefficient of the interaction term between the digital economy index and household population structure is not significant, suggesting that different household population structures do not lead to significant variations in the influence of the digital economy on household resilience. This is attributed to China's ongoing efforts in poverty alleviation projects and rural livelihood enhancement, with a focus on vulnerable groups such as the elderly, women, children, and disabled individuals. These initiatives ensure that households facing challenges due to a higher consumption-to-labor ratio can still receive appropriate support and protection.

5.1.2 Housing property rights characteristics

Rural housing serves as a symbol reflecting local economic development and the prosperity of rural residents. Since the reform and opening up, with the rapid development of China's rural economy, increasingly affluent farmers have shown a growing interest in building houses. This has led to a surge in self-built houses in rural areas, fulfilling the long-standing aspiration of farmers for suitable and comfortable living conditions. Simultaneously, the introduction and promotion of co-owned property rights have provided rural residents with diverse options for home purchase. Additionally, the recent growth of the rural housing rental market has prompted economically constrained or those inclined toward flexibility to opt for rental housing. In essence, the regulatory and systematic evolution of the rural housing market has made property rights a vital component of rural housing. Therefore, 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 constructs an interaction term between the digital economy index and housing property rights

attributes[5]. 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 is significantly positive. This suggests that for households living in co-owned or rental properties, compared to those residing in self-owned houses, the adverse impact of the digital economy on their household resilience is more pronounced. In other words, rural households with more comprehensive control over their housing property rights appear to navigate the digital economy era more adeptly, with a lower likelihood of their resilience being compromised. Hence, further clarifying rural homestead and housing property rights can better safeguard the property rights and interests of rural households, providing them with peace of mind in the era of the digital economy.

Table 6 Heterogeneity analysis results

Variable	(1)	(2)	(3)
Digital economy index	-0.0387***	-0.0346**	-0.0977***
	(0.0135)	(0.0138)	(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
Observation	10722	10441	7236

5.2 Mechanism analysis

The subsequent sections of this study endeavor to deconstruct the mechanisms through which the impact of the digital economy on rural household resilience operates, focusing on the integrated effects of employment, income structure, and member safeguarding. In terms of empirical methodology, drawing inspiration from the insights of Hicks et al. [62], we introduce mechanism variables into the baseline regression to discern the presence and direction of these mechanisms by observing changes in the estimated coefficients of the core explanatory variable. Specifically, when incorporating a mechanism variable into the benchmark regression leads to a relatively diminished absolute value of the coefficient of the digital economy index, it signifies a positive transmission mechanism by which the digital economy influences rural household resilience. Conversely, when the inclusion of a mechanism variable amplifies the absolute value of the coefficient of the digital economy index, it indicates a negative transmission mechanism in the influence of the digital economy on rural household resilience.

Taking a cue from the approach of Wang et al. [63], 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:

$$\varepsilon = \frac{\Delta N/N}{\Delta G/G} \tag{10}$$

In the formula, ε represents the employment elasticity of digitally driven industries, N stands

[5] Fully independent ownership = 1; Shared ownership with institutions (including government-provided, institution-provided, provided by parents or children, temporary residence with relatives, shared ownership with government, other) = 2; Rental accommodation = 3. The ascending numerical sequence reflects the degree of rural households' mastery over housing property rights.

for the number of employments generated by digitally driven industries, and *G* signifies the output value created by digitally driven industries. The requisite data for computation is sourced from the *"China Statistical Yearbook"*.

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 digitization 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 digitization index is significantly positive at the 1% significance level. This indicates that the advancement of the digital economy contributes 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 is 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 digitization index in Columns (3) and (5) of Table 7 experiences a noteworthy increase. This implies that both employment elasticity and the non-agricultural income proportion constitute negative mechanisms through which the digital economy impacts rural household resilience. In other words, to a certain extent, these mechanisms restrict the erosion of rural household resilience by the digital economy. In summary, Hypotheses 2 and 3 are validated.

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

Variable	(1)	(2)	(3)	(4)	(5)
Digital economy index	-0.0318**	9.3481***	-0.0342***	0.1257***	-0.0322**
	(0.0129)	(0.7586)	(0.0128)	(0.0457)	(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	10722	10722	10722	10034	10034

Following the analytical approach of the theoretical analysis section, we proceed to utilize 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 digitization index on female employment. The estimated coefficient is significantly negative at the 5% significance level, signifying that the current trajectory of digital economic development is not particularly favorable for women. Rural women still encounter a range of productive and social challenges as they engage with the forefront of digital technology and enter digital economic sectors. While aspects such as the decreasing entry barriers in digital economic formats like agricultural e-commerce enable easy access for rural women, the intensifying competition and the increasing demand for sophisticated

digital skills present formidable hurdles. Concurrently, gender barriers targeting rural women have not been fully dissolved, and the traditional division of labor within households, characterized by the "male breadwinner, female homemaker" model, still exerts influence in the digital economy era [64]. Further insight is 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 digitization index experiences a significant decrease. This implies that the enhancement of female employment levels constitutes a negative mechanism through which the digital economy influences rural household resilience. To be specific, the dual propulsion of female employment probability and stability serves to foster an enhancement in rural household resilience.

Secondly, as shown on Column (4) of Table 8, the impact of the digitization index on care pressure is explored. The estimated coefficient is significantly negative at the 1% significance level, indicating that the digital economy significantly reduces 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 alleviates the pressures of daily life but also substantially improves 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 digitization index sees a significant increase. This suggests that care pressure constitutes a negative mechanism through which the digital economy influences rural household resilience. To clarify, a certain degree of elevated care costs poses a hindrance to the development of rural household resilience. To conclude, Hypothesis 4 is verified.

Table 8 Mechanism analysis results: member security effect

Variable	(1)	(2)	(3)	(4)	(5)
Digital economy index	-0.0318**	-0.1931***	-0.0310**	-1.6374***	-0.0340**
	(0.0129)	(0.0436)	(0.0139)	(0.1677)	(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	10722	9162	9162	7986	7986

6 Conclusion and discussion

This study is founded upon microdata from the China Labor-force Dynamics Survey (CLDS) for the years 2012, 2014, 2016, and 2018. For the first time, it systematically computes the Rural Household Resilience Index, investigates the impact of the digital economy on rural household resilience, and dissects the group disparities and underlying mechanisms. The primary findings of this research are as follows:

(1) From 2012 to 2018, the rural household resilience index in China displayed notable temporal and spatial disparities. Over time, there was an overall trend of fluctuating improvement, while spatially, it exhibited a clustered distribution pattern. Employing the random forest algorithm, significant indicators influencing the rural household resilience index were identified, including village market, gentry assistance, economic organization, and income from collective operation.

(2) The elevation of the Digital Economy Index to a certain extent restrained the advancement of the Rural Household Resilience Index. A series of robustness tests, encompassing double-sided

truncation, exclusion of municipal samples, segmentation based on digital economy dimensions, and instrumental variable methods, corroborated the reliability of these findings.

(3) Heterogeneity analysis unveiled that within the Chayanov framework, larger household sizes intensified the detrimental influence of the digital economy on rural household resilience. However, variations in household population structure did not yield conspicuous differences in the impact of the digital economy. Additionally, households possessing more comprehensive housing property rights demonstrated a lower susceptibility to resilience erosion when facing digital economic challenges.

(4) Mechanism analysis revealed that the digital economy further affected rural household resilience through employment comprehensive effect, income structure effect and member security effect.

Against the backdrop of the digital economy gradually emerging as a crucial force in the national economy, exploring how to fully leverage the dividends of the digital economy, overcoming its adverse effects on rural household resilience, and enhancing their ability to withstand risk shocks holds significant importance. This will not only consolidate and expand the achievements in poverty alleviation but also propel high-quality development in agriculture and rural areas. It aligns with the comprehensive advancement of the rural revitalization strategy. Taking into account the aforementioned research findings, the following policy insights are derived:

Firstly, seize the opportunities of digital economy development era to elevate agricultural digitization levels and fortify rural household resilience. Harnessing the convergence of digital economy development and deep integration with agricultural economy, leverage various dimensions of novel digital technologies to revamp traditional agriculture across the entire value chain. Implement initiatives such as "digital agriculture" and "smart supply and marketing," accelerate the advancement of intelligent agricultural production and networked operations, enhance total factor productivity, and emphasize the fusion of emerging technologies like big data, artificial intelligence, and blockchain with agriculture. This empowers agriculture with efficiency and scientific precision while enabling rural inhabitants to share in digital dividends, thereby stabilizing their income sources.

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. In recent years, various regions have vigorously promoted digital economy development in response to prevailing trends. However, strategies for digital economy development cannot be universally applied. What may yield favorable outcomes in one locale may not necessarily be suitable for others. Developing a digital economy that contradicts the actual circumstances of a region may further compromise rural household resilience, escalating the risk of relapse into poverty. Therefore, local governments, especially when formulating strategies for rural digital development, should consider local factors such as demographic structure, household size, economic development level, and social-cultural aspects. This will ensure the strategy aligns with the local rural household resilience capacity, maximizing the benefits of the digital economy dividend.

Thirdly, innovate talent systems and mechanisms, unleashing innovation vitality and encouraging talented individuals to return to rural areas. In the digital economy era, rural household sizes are diminishing, and rural populations are experiencing lower birth rates and aging. The rapid development of urban digital economy provides enhanced employment opportunities for rural laborers in cities, leading to a reduction in the proportion of labor and non-labor populations in rural areas. This situation weakens rural household resilience. Consequently, innovating rural talent

construction mechanisms becomes imperative. Encourage rural laborers to return to their hometowns, support new employment channels in the era of rural internet, and foster industries like rural live-streaming e-commerce. Provide policy incentives and preferential treatment for young talents undertaking entrepreneurship in rural areas. This will invigorate employment and entrepreneurial energy in rural labor forces, further enhancing the scientific literacy of contemporary rural residents, infusing talent vitality into rural development, and addressing challenges brought about by smaller household sizes and aging population structures.

Lastly, propel high-quality development of agricultural insurance, formulate targeted policies, and enhance rural household resilience capacity. Within the context of the digital economy, rising costs of raising and supporting families coupled with the emergence of the "dual-income" model in households, as women increasingly enter the labor market, can result in reduced family backup support. This diminishes the ability to withstand disasters and unforeseen circumstances, weakening rural household resilience. Governments should intensify their support for rural households through the expansion of agricultural insurance coverage. Extend coverage to households vulnerable to major unexpected events and high risk of relapse into poverty. Develop precise and differentiated insurance policies to establish a safeguard mechanism for rural households. For households with lower economic resilience, enhance unemployment or disaster insurance coverage. This will provide economic support and protection to households facing abrupt income reductions due to sudden events like unemployment, illness, or disasters. Such measures will enhance household resilience, preventing a relapse into poverty.

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