

2023

## Can Digital Village Construction Help Upgrade Rural Household Consumption? An Empirical Examination Based on China's Rural Household Survey Data

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### Recommended Citation

Peiyu, Shao; Hui, Liu; Yang, Wang; and Changjun, Liu (2023) "Can Digital Village Construction Help Upgrade Rural Household Consumption? An Empirical Examination Based on China's Rural Household Survey Data," *Contemporary Social Sciences*: No. 4, Article 1.

DOI: <http://dx.doi.org/10.19873/j.cnki.2096-0212.2023.04.001>

Available at: <https://css.researchcommons.org/journal/vol2023/iss4/1>

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# *Can Digital Village Construction Help Upgrade Rural Household Consumption? An Empirical Examination Based on China's Rural Household Survey Data*

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**Abstract:** Digital village construction opens a new vista for fulfilling consumption capabilities and optimizing consumption patterns in rural areas. For this research, we used the microdata on rural households from the 2019 China Household Finance Survey (CHFS) to conduct an empirical examination of the impact of digital village construction on the upgrading of rural household consumption and its possible influence mechanisms in the endogenous switching regression (ESR) model. Our research findings can be summarized in three points. First, digital village construction has significantly contributed positive contributions to the improvements and upgrading of rural household consumption. Second, digital village construction can help upgrade rural household consumption by increasing their participation in online shopping and expanding online shopping channels. Third, digital village construction means different things to rural households at different levels of risk exposure, with its facilitation to consumption upgrades in proportion to income risks facing rural households. Our research findings, which came from an extensive, in-depth exploration of the factors influencing rural household consumption, are of practical significance and policy value to the stimulating and fulfilling of consumption potentials among rural households.

**Keywords:** digital village, consumption upgrades, influence mechanisms, endogenous switching regression (ESR)

**DOI:** <http://dx.doi.org/10.19873/j.cnki.2096-0212.2023.04.001>

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This paper is an achievement of the “High-quality Development, Credit Assets, and Digital Economy” project (KY2023E0122) funded by the Beijing Academy of Social Sciences, and of the Sichuan Philosophy and Social Science Planning project (SC21B0310), and is also part of a technological innovation capacity building program (KTYTD202233) and a college students’ innovation and entrepreneurship program (202310621238, 202310621243), both of which are supported by Chengdu University of Information Technology.

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## Introduction

Since the introduction of the reform and opening up policy (in late 1978), exports and investments, as two of the “three major demands,” have played a pivotal role in the development of the Chinese economy (Wang et al., 2019). The rapid growth of the Chinese market economy, along with the steady increases in urban and rural per capita incomes, is giving prominence to consumption as a major driver of economic growth in China (Ren et al., 2018). Relevant data from the National Bureau of Statistics of China show that in 2021 the “three major demands,” namely, consumption, investments, and net exports increased economic growth by 5.3 percent, 1.1 percent, and 1.7 percent, respectively, and contributed 65.4 percent, 13.7 percent, and 20.9 percent to economic growth, respectively, and that from 2011 to 2021, the annual contribution of consumption to the Chinese economy had been over 50 percent, which was far more significant than that of investments and exports. The annual central rural work conference in late 2020, emphasized the need to build a new development pattern, shift the strategic focus to the expansion of domestic demand, and make great progress in the vast rural areas. Building a new development pattern requires boosting rural consumption and giving full play to the strategic support of rural demands.

At the micro level (i.e., the household level), consumption is a direct source of happiness and a sense of gain among the people. As socialism with Chinese characteristics has entered a new era, the principal contradiction facing Chinese society has evolved. What we now face is the contradiction between unbalanced and inadequate development and the people’s ever-growing needs for a better life. The people’s higher-level needs can only be met through consumption growth and upgrades. At the macro level (i.e., the state level), China’s economic development has entered a “new normal.” Since consumption is a prerequisite for economic growth, China urgently needs to boost domestic demands and consumption. Only by continuously optimizing the consumption patterns and improving the consumption environments can China develop an endogenous impetus for economic growth and ensure the smooth functioning of our national economy. Thanks to rural reform, the income of rural households has increased significantly. However, due to the separate urban-rural structures, there is still an obvious gap in consumption between urban and rural areas. Generally, rural households in China tend to spend less and save more. Although China’s 500 million rural population means a huge rural consumer market, the underdevelopment in rural areas makes it difficult to stimulate rural households to buy more (Gao & Wang, 2016), resulting in sluggish rural consumer demand. Thus, it is imperative to increase rural consumer demand and upgrade rural consumption options.

The rural revitalization strategy was first presented at the 19th National Congress of the Communist Party of China. To bring the benefits of digital transformation also to rural households, the CPC Central Committee and the State Council further issued the *Outline of*

*Digital Village Development Strategy* as a total concrete solution to the digitalization of villages. Before the policy was introduced (in 2019), the new-generation digital terminals (smartphones in particular) and the 4G networks enabling such products had already pervaded rural China in 2020, paving the way for digital village construction. Digital village construction, which is an integral part of China's rural revitalization strategy, is about continuing the removal of institutional obstacles to the development of rural consumer markets to help expand and upgrade rural household consumption in the era of the digital economy. When it comes to relevant academic studies, however, little literature delves into the impact of digital village construction on rural consumption. How exactly can digital village construction influence rural household consumption? Through what channels does this impact work? A rigorous empirical examination of these issues can help assess the results of digital village construction, make optimal adjustments, allow rural households to benefit from digital village construction, and, more importantly, offer empirical evidence and insights into the fulfillment of rural consumption potential and the creation of new dynamics for economic growth.

### **Literature Review and Research Hypotheses**

Consumption has been a key area of concern among Chinese public services and academia in recent years and is also a constant consideration at the center of household decision-making. The existing literature on consumption mainly falls into two categories. The first category is about examining factors that influence household consumption. According to relevant studies, there are numerous factors (at both macro and micro levels) influencing household consumption. Macro factors include the degree of urbanization (Lei & Gong, 2014), technological innovation (Sun & Xu, 2018), and tax policy (Xu & Chen, 2015), while micro factors include household income (Lin, 2011), household assets (Li & Chen, 2014), financial portfolios (Yi et al., 2020), and retirement incomes (Zou & Yu, 2015). The second category is about examining the characteristics of household consumption in different dimensions. The research findings reveal that Chinese households have kept increasing their spending on education, healthcare, and cultural life (Chen, 2013), that household consumption varies from age group to age group (Zhu & Wei, 2016), and that the purpose of urban household consumption is shifting from subsistence to development and recreation (Wei et al., 2017; Shi et al., 2019).

Given that the above literature focuses on urban household consumption, there is a need to attach more importance to the study of rural household consumption. After more than 30 years of explosive growth, modern information, and communications technology (ICT) has gradually penetrated all aspects of work and life, becoming a core driver of social development. Digital village construction is one of the feasible solutions to the "three rural issues" (i.e., issues concerning agriculture, countryside, and farmers) in China. It is primarily about enabling the high-quality development of rural areas through digital technology (Xia et al., 2019). Consumption

is an important goal of work and life, and the results of digital village construction are sure to be manifested in rural consumers' behavior. The implementation of the digital rural development strategy in China is conducive to the development of rural communications infrastructure, rural logistics and storage systems, rural e-commerce activities, and rural digital financial inclusion, which subsequently creates a strong desire to buy in rural areas and profoundly shapes rural consumer perceptions and habits (Jiang, 2017). Based on the above analysis, the following hypotheses are proposed:

Hypothesis 1: In the context of digital village construction, the popularity and use of digital terminals can help upgrade rural household consumption.

Regarding the significance of digital village construction in fulfilling rural consumption potential, the existing studies mainly focus on two aspects: the effect of credit constraints and the reduction of transaction costs (Yi & Zhou, 2018). The study of the effect of credit constraints reveals that with digital villages still under construction, the percentage of rural households using digital terminals for online lending or financial management is not high (Leng & Chen, 2017). Instead, with reduced transaction costs, the increase in digital payment and online shopping volume has become an important manifestation of digital village construction. On the one hand, digital village construction involves building logistics and transportation corridors to develop logistics systems more convenient for online shopping and mobile payments (Li et al., 2020). On the other hand, digital village construction can generate diverse consumer service products in areas such as medical care, education, and entertainment (e.g., developmental and recreational consumption) to raise the overall consumption level (Zhang & Xu, 2019). Based on the above analysis, the following hypothesis is proposed:

Hypothesis 2: Digital village construction can help upgrade rural household consumption through online shopping channels and digital payments.

## **Research Design**

### **Data Source**

We used data from the 2019 China Household Finance Survey (CHFS), a nationwide survey conducted by the Survey and Research Center for China Household Finance, Southwest University of Finance and Economics. The survey was a large-scale systematic tracking survey that aimed to enable a comprehensive understanding of the financial well-being of Chinese households at the micro level, such as dynamic information on households' demographic characteristics, assets and liabilities, income and expenses, and insurance coverage. The survey was conducted in a stratified three-stage sampling approach, with a sample size in proportion to the population size. The sample data were compared with those from the National Bureau of Statistics and proved reliable.

The 2019 CHFS, as the most recent survey available, allows us to learn more about Chinese

households.<sup>①</sup> The 2019 CHFS covered a total of 107,008 persons from 34,643 households in 1,360 villages (communities) under 343 county-level divisions (i.e., counties, county-level cities, and districts) in 29 provincial-level divisions (i.e., provinces, autonomous regions, and municipalities directly under the central government) across China, exclusive of Tibet autonomous region, Xinjiang Uygur autonomous region, Hong Kong SAR, Macao SAR, and the Taiwan region. The survey data was representative at the national and provincial levels, supporting this study strongly. The survey collected comprehensive information on household consumption with sufficient answers to specially designed questions regarding the use of digital terminals (smartphones and computers) by households. The micro-level data ensured the accuracy and credibility of our empirical analysis. In terms of sample screening, we excluded sample households whose total household income and net assets were in the top 1 percent or bottom 1 percent, sample households whose heads were aged below 16 or above 80, and sample households whose information contained missing values in control variables before finalizing the information of 17,326 rural households.<sup>②</sup>

## Variable Selection and Descriptive Statistics

### *Variable selection*

**Dependent variable: Developmental and recreational consumption.**

Regarding the measurement of rural household consumption expenditures, we referred to the classification of consumption by the National Bureau of Statistics and divided rural household consumption into eight types, namely; (a) food consumption, (b) clothing consumption, (c) residential consumption, (d) household equipment and services consumption, (e) transportation and communication consumption, (f) educational, cultural, and recreational consumption, (g) healthcare consumption, and (h) other consumption. The total consumer spending should be the sum of the eight household consumption types.<sup>③</sup> We followed the practice of previous studies (Zou et al., 2013) to categorize four (of the above eight consumption types), namely, food consumption, clothing consumption, residential consumption, and healthcare consumption as subsistent consumption, and the other four types as developmental and recreational consumption (hereinafter referred to as D&R consumption).<sup>④</sup> The consumption pattern was expressed as the proportion of D&R consumption to total household consumption. The upgrade of rural household consumption was measured according to changes in the amount and proportion of D&R consumption. For rural households, more spending on development and recreation and a higher proportion of this consumption category indicate a pattern of higher level

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① The results of the sixth CHFS, completed in 2021, remained unavailable to the public when this study was done. So, we used the 2019 data for empirical analysis.

② In this paper, a rural household refers to a household whose head is registered as a rural resident.

③ Due to space limitations, more information on the eight consumption types in the CHFS questionnaire is shown in Schedule 1 of the Appendix.

④ Residential consumption in this paper mainly includes rent and utility bills (for water, electricity, gas, property management, etc.). Expenditure on home purchase is deemed property held (i.e., part of household assets), and is therefore not counted as part of consumption.

household consumption.

**Treatment variable: Digital terminal use.**

We examined the impact of digital village construction on rural households according to their use of digital terminals. More specifically, we measured the breadth of digital terminal use in the dimension of quality, and the depth of it in the dimension of quantity, to examine the impact of digital village construction on rural household entrepreneurship.

In the dimension of quality, we measured the breadth of the impact of digital village construction on rural households according to their use of digital terminals (smartphones and computers). This breadth depended on two choice questions in the 2019 CHFS questionnaire. Question 1 in the technology-enabled life part asks, “What cellphone are you currently using? (a) Smartphone; (b) Non-smartphone; (c) No cellphone.” Question 2 about household durables in the non-financial assets part is as follows: “Which of the following durables do you have in your home, and what is the purchase price of each?” Corresponding answer options contain the use and price of cellphones, computers (desktops, laptops, tablets, etc.), and TV sets. We created a dummy variable concerning digital terminal use based on the respondents’ answers to the above two questions. The value should be “1” for smartphone users or computer users. Otherwise, it should be “0.” We created a treatment variable in the dimension of quality and applied the endogenous switching regression (ESR) model to estimate the significance of digital terminal use to the upgrade of rural household consumption.

In the dimension of quantity, we measured the depth of the impact of digital village construction on rural households according to the market value of digital terminals (smartphones and computers) used by them. More expensive digital terminals generally feature better performance and more functions, bring easier and faster access to network information, and therefore allow users to take more advantage of services enabled by digital village construction. Using the responses to question 2, we calculated the total market value of cellphones and computers held by the respondents, and then took the logarithm of the variable in the later model estimation. We selected instrumental variables in the quantity dimension and used two-stage least squares (2SLS) to test whether the use of digital terminals could influence the upgrade of rural household consumption.

Table 1 Descriptive Statistics on Consumption Upgrade

Use of digital terminals	D&R consumption expenditure (In RMB)	Percentage of D&R consumption expenditure (%)
Using digital terminals	2.812 28,120	35.586
Not using digital terminals	0.856 8,560	22.197
Full sample size	2.15 21,500	31.05

*Note:* Calculation based on the 2019 CHFS data.

Table 1 indicates that rural households spend an average of RMB21,500 on development and recreation, accounting for about 31 percent of their total consumption expenditures. Rural households using digital terminals have an average D&R consumption expenditure of RMB 28,120, accounting for about 35 percent of their total consumption expenditures. By contrast, for rural households not using digital terminals, their average D&R consumption expenditure is RMB8,560, accounting for about 22 percent of their total consumption expenditures. Digital terminal users far outperform non-users in both the amount and proportion. In short, using digital terminals helps increase high-quality consumption expenditures and their proportion of the total rural household consumption expenditures.

#### Control variable.<sup>①</sup>

In this paper, control variables concerning household consumption fall into three categories: household characteristics, household head characteristics, and regional characteristics. The first category (i.e., household characteristics) includes household income, assets, social capital, privately-owned business, household size, and number of employed household members. The second category (i.e., household head characteristics) includes a household head's age, age squared, level of education, health, place of residence, engagement in agriculture, gender, marital status, and political affiliation. The third category (i.e., regional characteristics) includes four economic regions: the eastern, central, western, and northeastern regions.<sup>②</sup> This division, coming from the *Statistical System and Classification Standards* issued by the National Bureau of Statistics in 2018, is based on the fact that heterogeneity exists between regions across the vast land of China in terms of economic development and consumption capacity. Accordingly, we created dummy variables to control the impact of regional differences on household consumption. We took the logarithm of household income, household assets, and social capital in the empirical. To examine the nonlinear effect of age, we divided the household head age squared by 100 before importing it into the model. For the household head's level of education, primary school education or below was taken as the reference group; for the economic region, the northeastern region was taken as the reference group.

#### Identifiable variable.

The ESR model's application presupposes the existence of exclusive identifiable variables, that is, an instrumental variable that influences only the selection equation and not the outcome equation (Cai & Xia, 2019). Following the practice of previous studies (Yin et al., 2015), we took the usage rates of digital terminals at the village level (exclusive of the sample rural households) as an instrumental variable to determine whether the sample

① Due to space limitations, the meanings and assignments of control variables are shown in Schedule 2 of the Appendix. Consumption, income, assets, and social capital are all annual variables.

② In this paper, the eastern region includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; the central region includes Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan; the western region includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang; the northeastern region includes Liaoning, Jilin, and Heilongjiang.



rural households used digital terminals. The validity of our identifiable variable (AKA instrumental variable) is underpinned by two points. First, rural China features a typical “vernacular society,” and there is a striking “herd behavior” in Chinese villages. Moreover, digital devices also reflect “economies of scale.” So, within a village where a large proportion of households use digital terminals, individual households are highly likely to use them. That is to say, individual rural households are influenced by other households around them when it comes to decision-making. Second, the average use rate of digital terminals in a village does not directly govern the consumer decisions there but acts on household consumption in a roundabout way, that is, by governing the channels of digital terminal use, thus satisfying the exogenous requirement. The instrumental variable was tested, and its validity was reported in the following empirical analysis.

#### *Descriptive statistics*

Table 2 shows the results of descriptive statistics on relevant variables. The average annual income per rural household is RMB52,500; the average household assets value is about RMB310,000; the penetration rate of digital terminals among rural households is 66 percent; the average household cash gifts for special occasions (festivals, holidays, weddings, funerals, etc.) is about RMB1,970; rural households engaged in industrial and commercial operations account for 11 percent; the average household size is three persons; each household has 1.8 employed persons on average. Moreover, the average age of household heads is 55 years old; of all household heads, 44 percent of them have received elementary school education, and only 3 percent of them have completed junior college education or above; households participating in online shopping account for 32 percent, with the average amount of online shopping reaching RMB968.

Table 2 Descriptive Statistics on Variables

Variable Name	Mean value	Standard deviation	Minimum value	Maximum value
Using smart terminals	0.66	0.47	0	1
Household income	5.25	5.61	0.043	39.639
Household assets	47.01	65.46	0.270	521.082
Social capital	1.97	4.98	0	304
Privately-owned business	0.11	0.32	0	1
Household size	3.36	1.65	1	15
Number of employed persons	1.88	1.10	0	8
Household head age	55.32	12.34	16	80
Primary school education or below	0.44	0.50	0	1
Middle school education	0.39	0.49	0	1
High school education	0.13	0.34	0	1
Junior college education or above	0.03	0.18	0	1

Variable Name	Mean value	Standard deviation	Minimum value	Maximum value
Health	0.36	0.48	0	1
Rural residence	0.59	0.49	0	1
Household head engaged in agriculture	0.41	0.49	0	1
Male	0.83	0.37	0	1
Married	0.88	0.33	0	1
Identity	0.11	0.31	0	1
Eastern region	0.33	0.47	0	1
Central region	0.25	0.43	0	1
Western region	0.33	0.47	0	1
Northeastern region	0.08	0.28	0	1
With online shopping experience	0.32	0.47	0	1
Online shopping expenditure	968.61	3807.18	0	1.50E+05

Schedule 3<sup>①</sup> shows the t-test results after grouping the respondents according to “whether being a user of digital terminals.” Column (1) and Column (2) are the mean values of corresponding variables for the rural households never using and using digital terminals. Column (3) is the difference in means between the two groups. Column (4) is the t-value. Although Schedule 3 highlights significant differences in the means of some variables regarding the use of digital terminals, it does not mean that the use of digital terminals causes such differences. To accurately demonstrate how much digital terminals can contribute to consumption upgrades, we must consider the selection bias caused by the samples’ “self-selection.” Given that, we conducted our empirical analysis in the ESR model.

## Modeling

### *Endogenous Switching Regression (ESR) Model*

A review of the literature reveals that numerous econometric methods are enabling the study of factors influencing rural household consumption and that, of those econometric methods, commonly used ones include the multiple linear regression model based on the ordinary least squares (OLS) and models dealing with the endogeneity of such factors (Peng & Huang, 2017). For our analysis, we focused on the impact of digital village construction on upgrading rural household consumption. If participation in digital village construction (i.e., use of digital terminals) is an exogenous variable, then an OLS-based model can objectively capture the impact of digital village construction on the (upgrade of) household consumption. However, as rational

① Due to space limitations, the descriptive statistics by group and the t-test results are shown in Schedule 3 of the Appendix.

economic persons, rural households decide whether to participate in digital village construction out of utility maximization under household constraints. Therefore, their decision to participate in digital village construction is a result of “self-selection” or a matter of endogeneity. Under such circumstances, an OLS-based model, which overlooks rural households’ self-selection bias, cannot generate unbiased and consistent estimates. Once the estimates of the impact of digital village construction on rural household consumption are selectively biased, the results’ credibility will be significantly compromised. The propensity score matching (PSM) method is often used to deal with sampling bias and the endogeneity of a variable. In our case, however, the PSM method could only control the impact of observable factors, not that of possible unobservable factors, which could govern rural households’ decision-making and subsequently give rise to “implicit bias” (Chen, 2014).

The treatment effect model could indeed help eliminate the samples’ self-selection bias. More specifically, the probability of rural households’ participation in digital village construction could be estimated and then included as a new independent variable in the outcome equation for estimation, thus eliminating the sampling biases caused by unobservable factors. Still, the treatment effect model overlooks the heterogeneity in consumption quantity (patterns) between rural households as participants and those as non-participants in digital village construction.

To accurately assess the impact of digital village construction on rural household consumption (patterns), we used the ESR model created by Lokshin and Sajaia (2004) to fill the gap in the above-mentioned method. The ESR model can consider the sampling bias arising from unobservable factors and estimate the equations for determining the consumption (patterns) of participants and non-participants in digital village construction, respectively. Moreover, the ESR model could further examine the causal link between digital village construction and rural household consumption based on the estimates within the potential outcome’s framework.

First, we constructed Equation (1) for determining high-quality rural household consumption (D&R consumption expenditures).

$$Y_i = \alpha C_i + \sum_{j=1}^n \beta_j X_{ij} + u_i \quad (1)$$

In Equation (1),  $Y_i$  denotes the consumption of rural household number  $i$ ;  $C_i$  is a dummy variable concerning the use of digital terminals (smartphones and computers) by household number  $i$ ;  $C_i = 1$  means rural household number  $i$  uses digital terminals, while  $C_i = 0$  means the opposite;  $X_{ij}$  denotes the other control variables that determine the high-quality rural household consumption, including household characteristics, household head characteristics, and regional characteristics;  $\alpha$  shows the degree of impact of digital village construction on the high-quality rural household consumption. Since being a user of digital terminals is not a random decision,

some unobservable factors can affect rural households' use and consumption of digital terminals, thus leading to sampling bias. In accordance with the ESR model, we constructed Equation (2) to determine the use of digital terminals by rural households.

In Equation (2),  $C_i^*$  is the latent variable of dummy variable  $C_i$ ;  $C_i = 1$  when  $C_i^* > 0$ ;  $C_i = 0$  when  $C_i^* \leq 0$ ;  $Z_{ij}$  is the factor determining rural households' use of digital terminals. It is worth noting that although vector  $Z_{ij}$  in Equation (2) can have the same variables as vector  $X_{ij}$  in Equation (1),  $Z_{ij}$  must contain at least one variable not belonging to  $X_{ij}$  (i.e., an identifiable variable) in order to make itself identifiable. All explanatory variables included in  $Z_{ij}$  can influence rural households' decisions as to whether to use digital terminals. However, at least one variable cannot directly govern high-quality rural household consumption and can only indirectly do so by governing the channels of digital terminal use. For that reason, identifiable variables can be used as instrumental variables for selecting variables. We constructed Equation (3) and Equation (4) for determining rural household consumption.

$$C_i^* = \gamma_j Z_{ij} + v_i \quad (2)$$

$$Y_{1i} = \sum_{j=1}^n \beta_{1j} X_{1ij} + \mu_{1i}, \quad C_i = 1 \quad (3)$$

$$Y_{0i} = \sum_{j=1}^n \beta_{0j} X_{0ij} + \mu_{0i}, \quad C_i = 0 \quad (4)$$

We also constructed two different equations, namely, Equation (5) and Equation (6), for determining rural household consumption corresponding to digital terminal users and non-users, respectively.

$$E(Y_{1i} | C_i = 1) = \sum_{j=1}^n \beta_{1j} X_{1ij} + \sigma_{\mu_1 v} \lambda_{1i} \quad (5)$$

$$E(Y_{0i} | C_i = 0) = \sum_{j=1}^n \beta_{0j} X_{0ij} + \sigma_{\mu_0 v} \lambda_{0i} \quad (6)$$

In Equation (5) and Equation (6),  $\sigma_v^2 = \text{var}(v)$ ,  $\sigma_{\mu_0 v} = \text{cov}(\mu_0, v)$ , and  $\sigma_{\mu_1 v} = \text{cov}(\mu_1, v)$ ;  $\sigma_v^2$  is standardized as 1 and  $v_i$  is a random error term whose expected value is 0. The sample data are observations, and there is no way to simultaneously observe the rural household consumption among the digital terminal users when not having access to digital terminals or to observe the rural household consumption among the non-users when having access to digital terminals. However, the ESR model in this study allows for the simultaneous estimation of consumption levels in the two counterfactual cases corresponding to the observations within a latent variable framework. Such simultaneous estimations are expressed as Equation (7) and Equation (8), respectively.

$$E(Y_{0i} | C_i = 1) = \sum_{j=1}^n \beta_{0j} X_{1ij} + \sigma_{\mu_{0V}} \lambda_{1i} \quad (7)$$

$$E(Y_{1i} | C_i = 0) = \sum_{j=1}^n \beta_{1j} X_{0ij} + \sigma_{\mu_{1V}} \lambda_{0i} \quad (8)$$

Regarding consumption upgrades, the average treatment effect (ATE) on rural households using digital terminals, namely, the average treatment effect on the treated (ATT), can be expressed as Equation (5) minus Equation (7).

Likewise, regarding consumption upgrades, the ATE on rural households not using digital terminals, namely, the average treatment effect on the untreated (ATU), can be expressed as Equation (8) minus Equation (6).

$$ATT = E(Y_{1i} | C_i = 1) - E(Y_{0i} | C_i = 1) = \sum_{j=1}^n (\beta_{1j} - \beta_{0j}) X_{1ij} + (\sigma_{\mu_{1V}} - \sigma_{\mu_{0V}}) \lambda_{1i} \quad (9)$$

However, the ATU estimates are not highly significant because they contain samples not using digital terminals, and the most important parameter for estimation is the ATT (Heckman et al., 1998). Given that, we constructed Equation (9), which estimates only the ATT to measure the contribution of digital terminal use to the upgrades of rural household consumption.

$$ATU = E(Y_{1i} | C_i = 0) - E(Y_{0i} | C_i = 0) = \sum_{j=1}^n (\beta_{1j} - \beta_{0j}) X_{0ij} + (\sigma_{\mu_{1V}} - \sigma_{\mu_{0V}}) \lambda_{0i} \quad (10)$$

### *Instrumental Variable Method*

For the robustness test, we further measured the depth of rural households' participation in digital village construction according to the market value of the digital terminals they used. It is generally perceived that more expensive digital terminals (smartphones and computers) feature better performance and more functions, bring easier and faster access to network information, and therefore allow users to take more advantage of services enabled by digital village construction. Yet, smartphones and computers' value belongs to endogenous variables. Thus, we followed the practice of previous studies (Yin et al., 2015) by taking the average market value of digital terminals in use at the village level (exclusive of the sample rural households) as an instrumental variable (IV) to determine the value of digital terminals used by the sample rural households. After that, we conducted the 2SLS estimation.

### *Probit Model*

For the mechanism identification, we constructed a dummy variable concerning rural households' participation in online shopping to test whether digital village construction could improve rural household consumption by boosting rural households' participation in online shopping. Since the dependent variable is a binary variable concerning participation in online

shopping, we adopted a probit model for analysis.

$$Y_i = 1(\alpha + \beta digit_i + \gamma X_i + \mu_i > 0) \tag{11}$$

Specifically,  $Y_i$  is a dummy variable concerning rural households' participation in online shopping, with participation equal to 1 and no participation equal to 0;  $digit_i$  is a dummy variable concerning rural households' ownership of smartphones and computers and is a core variable of interest in this study;  $X_i$  denotes control variables which fall into three categories (i.e., household characteristics, household head characteristics, and regional characteristics);  $\mu_i$  is a random error term,  $\mu_i \sim N(0, \sigma^2)$ ;  $\alpha$ ,  $\beta$ , and  $\gamma$  denote vectors of coefficient estimates.

*Tobit Model*

For the mechanism identification, we further tested whether digital village construction could help upgrade rural household consumption by acting on their online shopping channels. As of the survey time, there was still a large rural population without any online shopping experience and with zero spending on online shopping, resulting in a typical truncated data set. Accordingly, we used the Tobit model for empirical analysis.

$$\begin{cases} Y_i = \max(0, y_i^*) \\ y_i^* = \alpha + \beta digit_i + \gamma X_i + \mu_i \end{cases} \tag{12}$$

Specifically,  $Y_i$  denotes rural households' online shopping spending;  $y_i^*$  denotes the sample rural households with online shopping spending greater than 0; the meanings of other variables are consistent with the probit model.

**Empirical Tests and Results Analysis**

*ESR Estimates and Analysis*

The Wald test for independence of variance rejects at the 1 percent level the original hypothesis that the selection equation for digital terminal use is independent of the decision-making equation for consumption upgrades (logarithm of D&R consumption expenditure). The fact that  $\rho_2$  is significantly different from zero at the 5 percent level indicates the presence of unobservable variables that affect both digital terminal use and D&R consumption expenditures. The above results justify our use of the ESR model in this study to test the significance of digital terminal use in upgrading rural household consumption.

Table 3 ESR Estimates

Variable name	Using digital terminals or not	D&R consumption expenditure (log)	
		Using digital terminals	Not using digital terminals
	(1)	(2)	(3)
Household income (log)	0.131***(0.012)	0.147***(0.009)	0.127***(0.014)
Household assets (log)	0.161***(0.010)	0.208***(0.008)	0.103***(0.012)

Variable name	Using digital terminals or not	D&R consumption expenditure (log)	
		Using digital terminals	Not using digital terminals
Social capital (log)	0.034***(0.003)	0.020***(0.002)	0.020***(0.004)
Privately-owned business	0.388***(0.049)	0.185***(0.025)	0.213***(0.075)
Household size	0.048***(0.010)	0.197***(0.007)	0.261***(0.012)
Number of employed persons	-0.016(0.016)	-0.002(0.011)	-0.030(0.019)
Household head age	0.043***(0.009)	-0.022***(0.006)	0.008(0.012)
Age squared/100	-0.084***(0.008)	0.000(0.006)	-0.016*(0.010)
Middle school education	0.305***(0.027)	0.092***(0.022)	0.022(0.033)
High school education	0.364***(0.041)	0.173***(0.029)	0.072(0.054)
Junior college education or above	0.566***(0.127)	0.381***(0.049)	-0.179(0.216)
Health	0.082***(0.026)	0.025(0.018)	-0.008(0.030)
Rural residence	-0.004(0.028)	-0.025(0.019)	0.034(0.029)
Household head engaged in agriculture	-0.113***(0.030)	-0.086***(0.022)	-0.012(0.034)
Male	-0.007 (0.034)	-0.049***(0.025)	-0.070**(0.034)
Married	0.006(0.038)	0.029(0.032)	-0.005(0.036)
Identity	0.222***(0.040)	0.074***(0.028)	0.012 (0.044)
Identifiable variable	0.952***(0.071)	—	—
Regional characteristics as a control variable	Controlled	Controlled	Controlled
$\rho_1$		0.046 (0.413)	
$\rho_2$		-0.195 (0.019)	
Goodness-of-fit test		2828.88***	
Log-likelihood value		-30603.713	
Test of independence		27.45***	
Number of samples		17326	

Notes: 1.\*\*\*, \*\*, and \* respectively indicate the levels of significance are taken at 1%, 5%, and 10%; 2. figures in parentheses are robust standard errors.

### *ESR Estimates and Analysis of the Use of Digital Terminals*

Column (1) in Table 3 shows the estimates of the selection equation. According to the estimates of the household characteristics as a control variable category, there is a significant positive contribution of household income, household assets, household social capital, engagement in privately-owned businesses, and household size to use digital terminals among rural households. According to the estimates of household head characteristics as a variable control category, the household head age squared is significantly negative at the 1 percent level. This means that the use of digital terminals first increases and then decreases with age. This trend is largely consistent with the reality of rural China, where the elderly prefer to obtain relevant information through interpersonal interactions and are less willing and less able to use smart terminals than the younger generation. The use of digital terminals rises significantly with the level of education received by the household heads. One possible explanation is that more

education enables rural individuals to better access and understand information, becoming more willing and able to use digital terminals. In addition, the use of digital terminals is more frequent among households whose heads are in good health; the use of digital terminals is less frequent among households whose heads are engaged in agriculture; no significant impact of household head gender or marital status was found for the use of digital terminals among those households.

#### *ESR Estimates and Analysis of Factors Influencing the Upgrade of Rural Household Consumption*

Columns (2) and (3) in Table 3 show the estimates of the outcome equation. According to the estimates in Column (2), for rural households using digital terminals, their D&R consumption expenditure is positively correlated to household income, household assets, social capital, privately-owned industrial and commercial businesses, and household size; there is an inverted U-shaped relationship between household head age and D&R consumption expenditure; rural households whose heads are well educated tend to spend more on development and recreation; rural households whose heads are engaged in agriculture tend to spend less on development and recreation. According to the estimates in Column (3), for rural households not using digital terminals, their D&R consumption expenditure is under the influence of household head age and gender, in addition to the positive influence of household income, household assets, social capital, privately-owned business, and household size. From the estimates in Table 3, the key contributors to the improvement and upgrade of household consumption include not just digital terminals but also household characteristics and household head characteristics. Accordingly, a multi-pronged approach needs to be taken to fulfill the consumption potential among rural households.

#### *ESR Estimates and Analysis of the ATE of Digital Terminals on Rural Households for Consumption Upgrading*

Table 4 shows the prediction of how much the use of digital terminals can contribute to upgrading rural household consumption based on the ESR estimates. The logarithm of D&R consumption expenditures for rural households using digital terminals is significantly higher by 0.877 compared to their counterfactuals, demonstrating a significant positive contribution of digital terminal use to high-quality household consumption. Figure 1 further illustrates the probability density function (PDF) plots corresponding to the two logarithms of D&R consumption expenditure for households using digital terminals and their counterfactuals. The contrast of the two plots gives a visual representation of the critical role of digital terminals in improving and upgrading rural household consumption. Based on the above analysis, Hypothesis 1 is verified.

Table 4 Average Treatment Effect of Digital Terminals on Rural Households in Logarithm of D&R Consumption Expenditure

	Number of samples	Mean value	Standard error value	T Value
$E(Y_{it}   C_i = 1)$	11464	9.6447	0.0063	—
$E(Y_{0i}   C_i = 1)$	11464	8.7679	0.0056	—
<i>ATT</i>	11464	0.8768	0.0084***	103.834

Note: \*\*\* indicates the level of significance is taken at 1%.



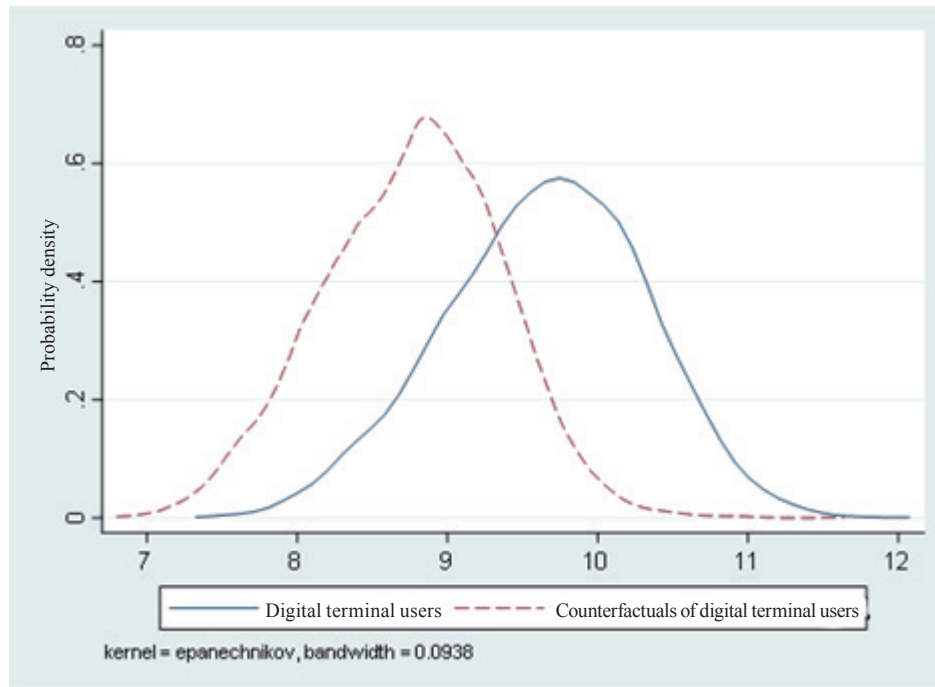


Figure 1 Comparison of the Distributions of Digital Terminal Users and Their Counterfactuals

### Identification of Influence Mechanisms

We created online shopping indicators in two dimensions, quality, and quantity, to examine whether digital village construction can help upgrade rural household consumption via online shopping channels. On the one hand, we created a dummy variable concerning online shopping in the quality dimension to measure the breadth of rural households' participation in online shopping. On the other hand, we created an amount variable concerning online shopping in quantity to measure the depth of rural households' participation in online shopping. A question is designed to obtain relevant information in the 2019 CHFS questionnaire. It reads like this, "How much did your family spend online shopping last year?" The descriptive statistics in Table 2 show that the online shopping penetration rate among rural households is 32 percent, and online shopping spending per household is RMB968. The results of descriptive statistics by the group in Schedule 3 show that, of the rural households using digital terminals, 45.5 percent participate in online shopping, with an average online shopping expenditure of RMB1,436, and that, of the rural households not using digital terminals, fewer than 7 percent participate in online shopping, with an average online shopping expenditure of only RMB55. Thus, it can be seen that there is a serious "digital divide" in the breadth and depth of participation in online shopping among rural households.

The estimates in Table 5 again confirm the findings of the descriptive statistics. Judging from the estimates in Column (1), rural households using digital terminals are 16 percent more likely

to participate in online shopping at the 1 percent significance level compared to rural households not using digital terminals. Judging from the estimates in Column (2), rural households using digital terminals perform 1.5 percent higher than those not using digital terminals regarding the elasticity of online shopping expenditure. Based on the results of descriptive statistics and the mechanism test, digital village construction can help upgrade rural household consumption via online shopping channels, thus verifying Hypothesis 2.

Table 5 Test Results of Influence Mechanism

	Online shopping or not	Online shopping expenditure (log)
	(1)	(2)
	Probit model	Tobit model
Using digital terminals	0.162***(0.008)	1.533***(0.067)
Control variable	Controlled	Controlled
Observed value	17343	17342
Pseudo $R_2$	0.3309	0.1586

Notes: 1.\*\*\* indicates the level of significance is taken at 1%; 2. Figures in parentheses are robust standard errors.

### Heterogeneity Analysis

For the heterogeneity analysis, we grouped the sample rural households according to their experience with income risks<sup>①</sup> to examine whether digital village construction affects rural households differently at different levels of risk exposure in terms of its facilitation to consumption upgrades. The estimates in Table 6 show that, of the rural households experiencing income risks, 2,482 households have digital terminals, with a treatment effect of 1.01 on consumption upgrades. The estimates in Table 7 show that, of the rural households not experiencing any income risks, 8,982 households have digital terminals, with a treatment effect of 0.83 on consumption upgrades. Based on the estimates in Table 6 and Table 7, we determined that digital terminals' facilitation of consumption upgrades is proportional to income risks facing rural households. In other words, digital terminals play a more crucial role in maintaining and upgrading rural household consumption under uncertain circumstances.

This is because using digital terminals can boost rural consumer confidence by reducing income uncertainty (Wang et al., 2021), which will encourage rural households to reduce precautionary savings and increase consumption. Also, using of digital terminals enables rural households to benefit more from digital finance. Thanks to the increased access to consumer loans and household credit, and the further reduction of household liquidity constraints, rural households can spend rationally even during mismatched incomes and expenditures.

① One of the choice questions in the CHFS questionnaire is: "How was your household's total income last year compared to 2016? (a) Increased a lot; (b) Increased a little; (c) No significant change; (d) Reduced a little; (e) Reduced a lot." By choosing (d) or (e), you are considered from a household at income risk.

Table 6 Average Treatment Effect on Rural Households Experiencing Income Risks

	Number of samples	Mean value	Standard error value	T-value
$E(Y_{it}   C_i = 1)$	2482	9.6224	0.0136	—
$E(Y_{0it}   C_i = 1)$	2482	8.6094	0.0115	—
ATT	2482	1.0129	0.0178***	56.975

Note: \*\*\* indicates the level of significance is taken at 1%.

Table 7 Average Treatment Effect on Rural Households Not Experiencing Income Risks

	Number of samples	Mean value	Standard error value	T-value
$E(Y_{it}   C_i = 1)$	8982	9.6508	0.0072	—
$E(Y_{0it}   C_i = 1)$	8982	8.8190	0.0065	—
ATT	8982	0.8318	0.0097***	86.1104

Note: \*\*\* indicates the level of significance is taken at 1%.

## Robustness Test

### *Robustness test: Redefining the explained variable.*

For the robustness test, we re-measured the upgrades of rural household consumption according to the proportion of D&R consumption to their total consumption. Table 8 shows the results of the robustness test with the replacement of the explained variable (AKA dependent variable). Row 3 in Table 8 shows the further prediction of how much the use of digital terminals can contribute to the upgrade of rural household consumption based on the ESR estimates. The proportion of D&R consumption expenditures for rural households using digital terminals is 8.9 percent higher compared to their counterfactuals, demonstrating a major contribution from digital terminal use to the upgrading of household consumption.

Table 8 Average Treatment Effect of Digital Terminals on Rural Households in Proportion to D&amp;R Consumption Expenditure

	Number of samples	Mean value	Standard error value	T-value
$E(Y_{it}   C_i = 1)$	11468	35.6556	0.0802	—
$E(Y_{0it}   C_i = 1)$	11468	26.7791	0.0501	—
ATT	11468	8.8765	0.0946***	93.828

Note: \*\*\* indicates the level of significance is taken at 1%.

### *Robustness Test: Redefining the Core Explanatory Variable*

Also, in the robustness test, we used the market value of digital terminals used by rural households to measure the depth of their participation in digital village construction. More expensive digital terminals (smartphones and computers) feature better performance and more functions, provide easier and faster access to network information, and therefore allow users to take more advantage of services enabled by digital village construction. Column (1) in Table 9 shows the results of the benchmarking regression. According to the results, a 1 percent increase in the value of digital terminals is associated with a significant 0.06 percent increase in D&R

consumption expenditures at the 1 percent level. Column (2) in Table 9 shows the instrumental variable (IV) regression results in light of endogeneity. The Durbin–Wu–Hausman (DWH) test indicates the existence of endogeneity, for which the estimates in Column (2) are more reliable. At this point, a 1 percent increase in the value of digital terminals used by rural households is associated with a significant 0.59 percent increase in D&R consumption expenditures at the 1 percent level. The estimates in Table 9 reconfirm that using digital terminals can make a robust positive contribution to the upgrading of rural household consumption.

Table 9 Robustness Test: Digital Terminal Value

	OLS	IV
	(1)	(2)
LN (digital terminal value)	0.062***(0.003)	0.589***(0.085)
Control variable	Controlled	Controlled
Observed value	17326	17326
$R_2$	0.4914	—
T-value for IV	—	7.52***
First-phase F-value	—	240.95***
DWH test	—	123.683***

Notes: 1.\*\*\* indicates the level of significance is taken at 1%; 2. Figures in parentheses are robust standard errors.

## Conclusion and Policy Recommendations

Although China's 500 million rural population means a huge potential rural consumer market, developmental and recreational consumption remains sluggish in rural areas. Given that, it is particularly imperative to increase rural consumer demand and upgrade rural household consumption. Digital village construction opens a new vista for fulfilling the consumption potential and optimizing consumption patterns in rural areas. In this paper, we used the micro data on rural households from the 2019 CHFS to conduct an empirical examination of the impact of digital village construction on the upgrade of rural household consumption and its possible influence mechanism using the ESR model. Our research findings can be summarized as follows. First, digital village construction has made a significant positive contribution to the improvement and upgrading of rural household consumption. Second, as revealed by our identification of influence mechanisms, digital village construction can help upgrade rural household consumption by increasing their participation in online shopping and expanding online shopping channels. Third, as revealed by our heterogeneity analysis, digital village construction means different things to rural households at different levels of risk exposure, with its facilitation to consumption upgrades in proportion to income risks facing rural households. Fourth, our findings still hold with the replacement of the dependent and core explanatory variables in our robustness test. Our

research findings also have four policy implications.

First, we should accelerate the building of rural communication networks to provide technical support for upgrading rural household consumption. Thanks to the continuous Internet penetration in rural areas, the percentage of digital terminal users in rural populations has been on the rise. Against such a backdrop, brick-and-mortar stores, with a limited variety of products, can no longer meet the needs of rural consumers, whereas online e-commerce platforms offer more choices. E-commerce platforms such as Taobao and Pinduoduo, well known for affordable products, are popular among rural households. By contrast, JD.com (also known as Jingdong) is preferred by rural households who are more quality-conscious about the products. Accordingly, we should continuously improve the rural digital economy's service system, perfect comprehensive services such as rural consumer-targeted advertising and mobile payments for better online shopping experiences, and raise the quality of rural household consumption through digital village construction.

Second, we should try to help rural households improve their digital literacy and skills. More specifically, we should continuously improve the network coverage and the quality of digital facilities in rural areas, increase rural household access to high-quality digital resources, and enable the offering and sharing of resources such as digital information services, digital education and training, and digital products among rural households. By doing so, we can bridge the digital gap between groups, between regions, and between urban and rural areas, create a sound and complete digital training system and a favorable digital learning environment, and allow rural households to improve their digital skills in social networking, online learning, and e-commerce.

Third, we should vigorously popularize the Internet Plus Agriculture model to expand sales channels for agricultural products and lay the material basis for rural consumption. We should use online platforms to promote organic agricultural products, sell local specialties via major e-commerce apps such as Taobao, Pinduoduo, and Shunfeng, and deliver agricultural products across China through rural logistics systems under construction. The purpose is to increase the business incomes of rural households and thereby improve the rural consumption pattern.

Fourth, we should strengthen the regulatory system for information connectivity markets to create a secure consumer environment. As online shopping involves a range of links (online payments, logistics, transportation, etc.), it may become a hotbed of fraud. Online consumption phenomena for recreational purposes, such as live-streaming tips, game top-ups, and pay-as-you-see video payment solutions, can create confusion and even chaos among China's rural households, which remain relatively weak in safeguarding their legitimate rights and interests. Given that, relevant government authorities should take immediate measures to strengthen supervision and crack down on Internet fraud to protect consumer rights and interests.

Due to data limitations, this paper only focused on the impact of digital village construction on the upgrading of rural household consumption and did not thoroughly explore the intrinsic mechanisms that determine the role of digital technology in such an upgrade. This research

limitation is the very area that needs to be studied further.

## Appendix

Schedule 1 Eight Household Consumption Types in the 2019 CHFS Questionnaire

S/N	Type	Details
1	Food consumption	Expenditures on meals, cigarettes, alcoholic and non-alcoholic beverages, and self-produced edible agricultural products
2	Clothing consumption	Expenditures on clothing for all household members
3	Residential consumption	Rent, utility bills (for water, electricity, gas, property management, heating, etc.), and costs of home renovation and maintenance
4	Household equipment and services consumption	Expenditures on durables, daily necessities, housekeeping services, and beauty services
5	Transportation and communication consumption	Vehicle expenses, local transportation expenses, and communication bill payment
6	Educational, cultural, and recreational consumption	Expenditures on education, entertainment, and tourism
7	Healthcare consumption	Expenditures on health protection and medical treatment
8	Other consumption	Expenditures on luxuries, legal services, and other matters

*Notes:* The following three points need to be clarified regarding the calculation of the indicators. First, this paper's total household consumption expenditure refers to consumption expenditure only (exclusive of property expenses, operating expenses, social security expenditure, and transfer payment). Second, local transportation expenses in this paper refer to all expenses arising from public and private transportation within the region (at the county or municipal level) where the respondent's residence is located. Third, as temporal frequency varied from consumption type to consumption type in the 2019 CHFS questionnaire, we collected relevant information from answers concerning household consumption in different periods, particularly the annual household consumption and the average monthly consumption in the previous year. If, for example, the statistical period for a particular question was the average month in the previous year, the corresponding consumption figure should be converted to the previous year's annual figure (i.e., annual consumption=average monthly consumption×12 months). Accordingly, the total household consumption expenditure and the eight consumption types' respective expenditures in this paper refer to those in the previous year (i.e., 2018).

Schedule 2 Definitions and Assignments of Control Variables

Control variable	Variable definition and assignment
Household income	Total household income (In RMB)
Household assets	Total household assets (as a control variable) comprise three parts: non-financial assets (land, vehicles, etc.), financial assets (deposits, stocks, funds, bonds, derivatives, etc.), and other assets (In RMB).
Social capital	Total expenditure on household cash gifts for special occasions (festivals, holidays, weddings, funerals, etc.) in the 2019 CHFS questionnaire was used to measure the social bonding of a rural household (In RMB).
Privately-owned business	Respondent as a private business owner=1, otherwise=0
Home ownership	Respondent as a rural home owner=1, otherwise=0
Household size	Number of persons living together in a family
Number of employed persons	Number of employed persons in a family
Household head age	In this paper, the household head's birth year was subtracted from "2019" to obtain age data.

Control variable	Variable definition and assignment
Primary school education or below	Primary school education or below=1, otherwise=0
Middle school education	Middle school education=1, otherwise=0
High school education	High school education=1, otherwise=0
Junior college education or above	Junior college education or above=1, otherwise=0
Health	In good health=1, otherwise=0
Place of residence	Respondent as a rural resident=1, otherwise=0
Household head engaged in agriculture	Household head engaged in agriculture=1, otherwise=0
Identity	CPC member=1, otherwise=0
Male	Male=1, otherwise=0
Married	Married=1, otherwise=0
Eastern region	Eastern region=1, otherwise=0
Central region	Central region=1, otherwise=0
Western region	Western region=1, otherwise=0
Northeastern region	Northeastern region=1, otherwise=0
With online shopping experience	With online shopping experience=1, otherwise=0
Online shopping expenditure	Amount of household online shopping expenditure (In RMB)

Schedule 3 Difference in Means of Variables

Variable name	Not using digital terminals	Using digital terminals	Difference in means	T-value
	(1)	(2)	(3)	(4)
D&R consumption expenditure	0.856	2.812	-1.956***	-39.851
Percentage of D&R consumption expenditure	22.197	35.586	-13.390***	-44.597
Household income	2.812	6.496	-3.684***	-43.019
Household assets	25.038	58.263	-33.225***	-32.587
Social capital	1.087	2.419	-1.332***	-16.800
Privately-owned business	0.032	0.156	-0.124***	-24.739
Household size	2.782	3.658	-0.876***	-34.161
Number of employed persons	1.602	2.027	-0.425***	-24.495
Household head age	63.831	50.959	12.872***	74.730
Primary school education or below	0.662	0.329	0.333***	44.013
Middle school education	0.265	0.460	-0.195***	-25.334
High school education	0.070	0.163	-0.093***	-17.300
Junior college education or above	0.003	0.048	-0.045***	-15.703
Health	0.245	0.417	-0.172***	-22.709
Rural residence	0.713	0.532	0.181***	23.357
Household head engaged in agriculture	0.548	0.347	0.201***	25.976
Male	0.814	0.842	-0.028***	-4.622
Married	0.826	0.901	-0.075***	-14.225

Variable name	Not using digital terminals	Using digital terminals	Difference in means	T-value
Identity	0.092	0.118	-0.027***	-5.349
Eastern region	0.297	0.354	-0.056***	-7.451
Central region	0.278	0.239	0.039***	5.579
Western region	0.345	0.322	0.023***	3.016
Northeastern region	0.080	0.085	-0.005	-1.190
With online shopping experience	0.068	0.455	-0.387***	-56.000
Online shopping expenditure	55.135	1436.495	-1381.361***	-22.954

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(Editor: Xu Huilan)