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Punjab Agricultural University, India
Sreeram Vishnu,
Kerala Agricultural University, India

*CORRESPONDENCE
Meifeng Zou
✉ zoumeifeng@tyust.edu.cn

RECEIVED 01 November 2024
ACCEPTED 24 March 2025
PUBLISHED 30 April 2025

CITATION
Zou M, Gao Y, Ma H and Zhang Y (2025) Does digital village construction promote rural residents' happiness?
Front. Sustain. Food Syst. 9:1518819.
doi: 10.3389/fsufs.2025.1518819

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Does digital village construction promote rural residents' happiness?

Meifeng Zou^{1,2*}, Yunfeng Gao¹, Hua Ma² and Yuefei Zhang³

¹School of Economics and Management, Taiyuan University of Science and Technology, Taiyuan, China, ²Shanxi University, Taiyuan, China, ³Taiyuan Satellite Launch Center, Xinzhou, China

Digital village construction (DVC) is a new form of development that uses emerging digital technologies and brings change to rural residents. This paper delves into the influence and mechanism of DVC on rural resident happiness utilizing the ordered Probit model, drawing on data from the China Family Panel Studies (CFPS). Our findings indicate a marked enhancement in rural residents well-being as a consequence of DVC, and the results remain robust after replacing *OLS* regression, changing the measurement of explanatory and explained variables, adding other control variables, and using *CMP* estimation. Heterogeneity analysis shows that the enhancement effect is significant in male, middle-aged and highly educated groups, while the effect is insignificant for young groups, low and middle education groups. The mechanism tests show that the DVC can improve the rural residents' happiness by increasing household income and reducing the loneliness. Government might amplify its investment and bolster digital infrastructure, enabling a greater number of rural residents to fully benefit from the development of a digital countryside.

KEYWORDS

digital village construction, rural residents' happiness, household income, loneliness, new opportunity

1 Introduction

The advent of the digital age has brought both opportunities and challenges to rural development (Grubestic, 2003). Digital village construction (DVC) is a new form of development that uses emerging digital technologies such as big data, internet of things, artificial intelligence, and cloud computing to reshape rural residents' production and life (Gabe and Abel, 2002). The DVC has brought benefits to rural residents in many ways. First, it has greatly increased rural residents' income by promoting digital transformation within agricultural production (Zhao et al., 2023), the reform of agricultural distribution systems, the evolution of business practices, the enhancement of rural services and governance, and the establishment of an information-rich rural social service system (Grubestic and Murray, 2004). Second, it fosters cross-regional collaboration and dialogue, as well as rural innovation and entrepreneurship, thereby generating a wealth of employment prospects and vocational openings (Oyana, 2011). This, in turn, is favorable in drawing a greater number of skilled individuals to return to their roots and embark on entrepreneurial ventures (Zhao et al., 2023). Third, through mobile intelligent devices, rural residents can quickly access information and get different ideas, which broadens the channels for obtaining happiness (Wu and Hu, 2024). Digital technology invigorates rural development, potentially fulfilling the escalating aspirations of rural residents for an enhanced quality of life (Malecki, 2004).

With the development of digital technology in rural region, scholars pay much attention on the economic consequences of the DVC. Scholars find that the DVC can promote rural residents' income (Zhao et al., 2023), increasing rural residents' consumption (Wang and Huang, 2023), reduce the income gap between rural residents (Zhou and Zhang, 2021), increase the probability of formal credit demand for rural household (Beck et al., 2018), broaden the channels of information acquisition enrich social networks and increase entrepreneurial probability (Lichter and Brown, 2011). However, scholars seldom pay attention to the impact of DVC on the subjective psychological state of rural residents, such as the happiness of rural residents.

A growing body of literature discusses the influence factors of rural residents' happiness, including internal and external factor. The internal factors include age, gender, personality, education level, marital status, family characteristics, personal income, etc. (Blanchflower, 2001; Liu et al., 2012; Chapman and Guven, 2016; Helliwell, 2003; Tempier et al., 2006). External factors include social security level, income gap, infrastructure, internet development and ecological environment, etc. (Veenhove, 1991; Dolan et al., 2008; Ram, 2009). However, few scholars have studied the relationship between the DVC and rural residents' happiness. Only Zhang and Yi (2023) found that the digital transformation of rural governance can improve the happiness of rural residents. Wu et al. (2023) pointed out that the development of rural electronics has improved the subjective well-being of rural residents. Although the above researches are somewhat similar to this paper, they focus more on a single aspect of the development of digital countryside, and pays less attention to whether DVC affects the happiness of rural residents, nor does it reveal the influence mechanism.

Therefore, this paper attempts to explore the impact of DVC on rural residents' happiness through theoretical analysis and empirical tests, further reveal its mechanism. We collect DVC data and rural residents characteristics data. The DVC data comes from "Index of Digital Rural County" database of Peking University New Rural Development Research Institute and Ali Research Institute. The data of rural residents' happiness uses China Family Panel Studies (CHPS) database released by Peking University and the National Natural Science Foundation of China. The two part of database were matched according to the sample's region, and a total of 8,187 sample data were obtained. Then, we construct a multiple regression model to examine the effect of DVC on the rural residents' happiness. A series of robust and endogeneity tests were carried out to obtain reliable results. Our findings indicate a marked enhancement in rural residents well-being as a consequence of DVC. Heterogeneity analysis reveals that the enhancement effect is notably pronounced in groups identified as male, middle-aged, and highly educated, whereas for younger demographics and those with low to moderate levels of education, the effect remains negligible. Furthermore, we reveal the mechanism of this improvement effect, and the study finds that DVC improve rural residents' happiness by increasing their income and reducing their loneliness.

The remaining of this paper is organized as follows. Section 2 describes the theoretical analysis and research hypotheses. Section 3 introduces the empirical model, variable measurement and sample sources. Section 4 is the empirical results. Section 5 presents additional analysis. In section 6, we concludes the paper.

2 Theoretical analysis and research hypothesis

2.1 The impact of DVC and rural residents' happiness

The DVC has changed the life style, working state and behavior mode of rural residents in an unprecedented way, and has a profound impact on the happiness of rural residents.

Firstly, the DVC broadens the sources of rural residents' information access. The *information gap theory* holds that unequal access to information will lead to the aggravation of social inequality (Matrosov et al., 2013). The DVC aims to reduce the information gap between urban and rural areas, enabling rural residents to also enjoy the convenience brought by digitalization, such as e-government and e-commerce, thereby reducing social inequality and enhancing the happiness of rural residents (Malecki, 2003). Relying on digital technologies such as big data and cloud computing, it is possible to effectively alleviate the information asymmetry rural residents (Kong et al., 2022). The big data technology has the function of efficiently capturing and integrating information (Liu and Tian, 2022). Meanwhile, the Internet platform can realize the multi-dimensional presentation and rapid sharing of information (Liu et al., 2021). According to the theory of information visualization, when information that is difficult to be directly displayed is transformed into forms such as graphics and videos for presentation, it can greatly enhance the individual's reception degree of information and expand the sources of information (Munzner, 2014). Rural residents through using of the internet enrich their knowledge and vision, absorb fresh ideas, so as to improve the happiness of them (Zhang et al., 2024). Ma and Le (2019) shows that digital development creates new activities such as online leisure and entertainment, online shopping, which improve the subjective welfare level of rural residents.

Secondly, the DVC improve rural residents' skills. The *technology acceptance model* explains how users accept and utilize a new technology (Davis, 1989). In DVC, as the acceptance of new technologies by rural residents increases, they can better utilize these technologies to enhance production efficiency (Zhao et al., 2024), obtain information, and enjoy services, thereby improving the quality of life and happiness (Hong and Chang, 2020). The DVC offers various online learning opportunities through the Internet, which can enhance the earning capacity of rural residents (Yin et al., 2024). Digital tools can equip rural residents with an abundance of knowledge regarding modern agricultural techniques, such as soil management, precision farming, and crop health monitoring, thereby enhancing their agricultural skills (Bai et al., 2024). Zhou and Zhang (2021) show that using the Internet can improve work ability. Ma and Le (2019) conduct empirical tests and find that online learning can significantly enhance the happiness of rural residents.

Thirdly, DVC broadens social network relationship of rural residents. The *social capital theory* indicates that social networks, norms, trust and other forms of social capital have a significant impact on the welfare of social members (Cook, 2001). The DVC enhances the internal connections within rural communities and their ties with the outside world by establishing a broader information network (Sabatini and Sarracino, 2017), thereby increasing social capital and improving residents' sense of happiness (Ma and Le, 2019). The use of digital technology facilitates the communication between rural residents (Castellacci and Vinas-Bardolet, 2019). The use of mobile Internet not only helps maintain existing strong relationships (Salanova et al., 2004),

but also forms new relationships, thus strengthening rural residents' social network relationships, enhancing their sense of self-worth, and enhancing rural residents' happiness (Castellacci and Tveito, 2018).

Based on the above analysis, we speculate that if DVC is high, rural residents will experience increased happiness due to easy access to abundant information, rapid skill improvement, and strong social relationships. Thus, we propose the hypothesis *H1*: the higher the DVC, the higher rural residents' happiness.

2.2 The mechanism of DVC impacts rural residents' happiness

Economic resources are the material basis of people's happiness. The rural residents may be increased economic resources by the DVC, further increase their happiness. On the one hand, the DVC broadens the channels for entrepreneurship, increases rural residents' income (Li et al., 2021). With the development of digital technology, rural residents can use the Internet platform to sell agricultural products abroad, which improves the value of agricultural products (Omrani and Martin, 2014). They can also use e-commerce, live video and other ways to start a new business, changing the traditional means of survival based on agriculture (Pénard et al., 2013). On the other hand, the DVC creates a variety of new job positions, and further promoted rural residents' income (Tu and Sui, 2011). In the past, rural residents, limited by remote geographical location, inconvenient transportation and other factors, often rely on farming for income. The income obtained from planting food has great uncertainty (Sabatini and Sarracino, 2017). On the contrary, nowadays, with the application and development of digital technologies, rural residents can use digital technologies such as *smart agriculture* for planting agriculture, reducing the failure rate of planting agriculture (Van Gaasbeek, 2008). Furthermore, digital technology sinks to rural areas and creates a lot of jobs (Calvet et al., 2009). For example, rural residents need a large number of anchors, operation personnel, security personnel, transportation personnel and after-sales personnel to sell agricultural products through live broadcasting platforms (Jin and Xing, 2024). All of these have greatly increased the employment rate in rural areas, achieved employment at the doorstep, obtained higher income, and greatly increased the happiness of rural residents (Ma and Le, 2019). Based on the above discussion, we propose the research hypothesis *H2*: the DVC can obtain happiness through rural residents' income.

Loneliness is a reflection of a closed mind, which is the feeling of isolation and exclusion from the outside world (Kraut et al., 1998). Loneliness is a feeling that rural residents are generally ignored by the public, and this feeling will undoubtedly affect the happiness of them (Castellacci and Tveito, 2018). They feel lonely, because their children leave the countryside and live in the city (Morrish, 2021). There are generally no recreational activities and social activities for rural residents (Diener et al., 1999). The DVC has a positive influence on reducing the loneliness of them (Nie et al., 2021). Through social media, instant messaging and other tools, DVC helps rural residents establish and maintain connections with family, friends and neighbors (Baric et al., 2018). Even if rural residents are in the countryside, they can enjoy similar social interactions with urban people, thus reducing their loneliness. Many elderly people learn to use smart phones, and sell agricultural products through the Internet (Brooks, 2015). The rural residents buy daily products, enjoy convenient remote services, which

not only improves their quality of life, but also increases the interaction with the outside world (Castellacci and Vinas-Bardolet, 2019).

Based on the above analysis, we propose the research hypothesis *H3*: the DVC can improve rural residents' happiness by reducing their loneliness.

3 Sample source and research design

3.1 Sample source

The data in this paper includes two parts. The first part is the Index of Digital Rural County (IDRC). The Index is released by the Institute of New Rural Development of Peking University and Ali Research, which is used to describe the development of Chinese county-level digital countryside (New Rural Development Institute, Digital Village Project Team, Peking University, 2020). Specifically, it has four sub-dimensions, including digital infrastructure index, digital rural economy index, digital rural governance index and digital rural general index.

The second part of the data comes from the China Family Panel Studies (CFPS) funded by Peking University and the National Natural Science Foundation of China. The CFPS is maintained by the Institute of Social Science Survey of Peking University. The CFPS data is organized and implemented by the China Social Survey Center of Peking University, using multi-stage equal probability sampling, the sample covered 162 counties in 25 provinces, and the target sample size was 16,000 households. 2010 was the base period for sampling and research, and the following survey is conducted every 2 years. The data utilized in this study pertain to the years 2018 and 2020, chosen specifically as IDRC data became accessible exclusively in these years.

The data is processed as follows: (1) Urban samples are excluded of CFPS and IDRC, only rural samples are retained. (2) Only family samples and matched household head characteristics are retained for CFPS. (3) Because the digital rural Index of Beijing, Tianjin, Shanghai and Chongqing is not collected in IDRC for 2018 and 2020, the samples of these four cities are deleted. Finally, we match IDRC with CFPS by county ID. The sample data of 8,187 rural households were obtained after removing incomplete or anomalous sample.

3.2 Variable measurement

The explained variable is rural residents' happiness (*Happiness*). Referring to the existing studies, the answer of "How happy do you feel?" of the CFPS2018 and 2020 questionnaires are used to evaluate the rural residents' happiness. Responses to this question are measured on a scale of 0–10, from "very unhappy" to "very happy" with higher scores indicating higher levels of happiness of rural residents.

The explanatory variable is DVC, which measured by Index of Digital Rural County (IDRC). The original value of IDRC ranges from 0 to 100. In addition, the empirical analysis part adopts the standardized DVC except the descriptive statistics part. The standardized method is to divide the raw data by 100.

The theoretical analysis and research hypotheses suggest that the mechanism by which DVC enhances the happiness of rural residents by augmenting their income (*Income*) and alleviating their sense of loneliness (*Lone*). In order to verify these two mechanisms, the

Income is measured by the average household income of CFPS. The *Loneliness* is measured by the question of “*I feel lonely in a week*” and its answer in the CFPS database. Replies to this query are gauged on a four-point scale, ranging from “1) Almost none (less than a day)” to “4) Most days (5–7 days).” This scale delineates four distinct tiers of frequency: “1) Almost none; 2) Some days; 3) Often; 4) Most days,” with ascending scores signifying intensified degrees of loneliness. “*Almost none (less than a day)*” to “*Most days (5–7 days)*.” This scale delineates four distinct tiers of frequency: “1) *Almost none (less than a day)*; 2). *Some days (1–2 days)*; 3). *Often (3–4 days)*; 4. *Most days (5–7 days)*,” with ascending scores signifying intensified degrees of loneliness.

To mitigate the impact of extraneous variables on the regression outcomes, and drawing upon extant research (Jiang, 2023), the control variables are principally categorized into two groups. One groups is to describe the rural resident characteristics, including age, gender, education level, marital status, health level, occupation, religious belief, social status, and whether there is medical insurance. Another category is to measure family characteristics, including the size of family, per income of the family (Li et al., 2021). Detailed descriptions of the variables, along with their descriptive statistics, are presented in Table 1.

3.3 Regression model

Considering that the dependent variable of this study, rural residents’ happiness, is ordinal and discrete, an *Ordered Probit* model

is employed for the estimation. To investigate the effect of DVC on rural residents’ happiness, Equation 1 is established.

$$\text{Happiness}_{i,j} = \beta_0 + \beta_1 \text{Dig}_j + \beta_2 \text{Control}_{i,j} + \varepsilon_{i,j} \quad (1)$$

Where *Happiness* represents the happiness of rural resident *i* in *j* county. *Dig* represents the level of DVC in County *j*. *Control* is a set of control variables. ε represents the random error term. This paper focuses on the β_1 coefficient. According to the above theoretical analysis and research hypothesis, we predict that β_1 is positive.

4 Empirical result analysis

4.1 Baseline results

Table 2 show the results of the *Ordered Probit Regression for model (1)*. In column (1), it does not include any control variables, the coefficient on DVC is 0.063, statistically significant and positive at the 1% level. In column (2), post inclusion of control variables, the coefficient of DVC on rural residents happiness is 0.0471, which remains significantly positive at the 1% level. This substantiates the assertion that DVC indeed elevates rural residents happiness, thus confirming hypothesis *H1*. Regarding the control variables, the majority exert a significant influence on rural resident happiness. Marital status, health condition, education level, social status,

TABLE 1 Descriptive statistics of main variables.

Variable	Variable definition	Number	Mean	S.D.	Minimum	Maximum
Rural resident happiness	0 ~ 10	8,187	7.275	2.280	0	10
DVC	Sum index	8,187	54.621	8.363	21.806	82.575
Rural digital infrastructure index	Sub-index	8,187	62.319	15.322	27.299	89.716
Rural digital economy index	Sub-index	8,187	47.065	8.032	19.521	66.438
Rural digital governance index	Sub-index	8,187	46.184	12.747	12.303	82.626
Rural digital living index	Sub-index	8,187	80.580	37.633	25.063	163.746
Age	rural residents age	8,187	51.144	13.908	16	91
Gender	1 = Male; 0 = Female	8,187	0.578	0.494	0	1
Education Level	0 = Illiterate/Semi-literate; 1 = Nursery; 2 = Kindergarten; 3 = Primary School; 4 = Middle School; 5 = High School/Vocational School; 6 = College; 7 = Bachelor’s Degree; 8 = Master’s Degree; 9 = Doctoral Degree; 10 = No Education	8,187	3.009	1.749	0	8
Marital status	1 = in marriage; 0 = other	8,187	0.847	0.360	0	1
Health status	1 = health; 0 = unhealthy	8,187	0.672	0.470	0	1
Employment	1 = employed; 0 = unemployed	8,187	0.846	0.361	0	1
Religious belief	1 = Have faith; 0 = no faith	8,187	0.031	0.173	0	1
Social status	1 ~ 5	8,187	3.223	1.111	1	5
Family size	The number of family	8,187	3.820	1.978	1	15
Medical insurance	1 = Have health insurance; 0 = No health insurance	8,187	0.930	0.256	0	1

participation in medical insurance, and household per capita income all have a notable positive impact on rural residents' happiness. Employment status, religious beliefs, and family size did not yield statistically significant effects on rural residents' happiness.

4.2 Robustness tests

(1) Replace regression model.

Based on the practice of Ferreri Carbonell and Frijters (2004), this paper considers rural residents happiness as a continuous variable and uses *Ordinary Least Squares* (OLS) as a benchmark regression. If the coefficient of *Dig* is positive, it indicates that the DVC increases the happiness of rural residents. Column (1) of Table 3 reports the OLS regression results, and it can be seen that the coefficient is 0.0988 and still significantly positive at the 1% level, which supports the hypothesis H1.

(2) Replace the measure of DVC

This paper also employs the questionnaire “*whether to access the internet via mobile*” from CFPS as an alternative measure for the DVC. This approach is due to potential reservations in the respondents' mindset or inconsistencies in the questionnaire response standards, which may introduce bias into the subjective appraisal of happiness. Column (2) of Table 3 shows the result. The coefficient of *Dig* is 0.0473, and remains positive and significantly.

(3) Replace the measure of rural residents happiness

To mitigate errors potentially arising during the survey, the recorded responses for the dependent variable, rural residents happiness, were reassigned. The adjustment protocol reclassifies responses indicating happiness levels from “0–5” as “0” and those from “6–10” as “1.” The *Probit* model was reapplied using model (1)

for estimation, with the regression results presented in Column (3) of Table 3. The findings suggest that even when the measurements for rural residents happiness are altered, the impact of the DVC on rural residents happiness remain robust.

(4) Add other control variables.

By referring to Jin et al. (2024), we further control other factors that may affect rural residents' happiness. Especially, we add rural residents' relative income, political status and mortgage status into the model (1). The results are shown in Column (4) of Table 3, and the coefficient of *Dig* is still significantly positive at 1% level. It indicates that the baseline results are reliable.

4.3 Endogenous problem

In the empirical tests, we employ the macro-level County Digital Village Index as the explanatory variable, while the explained variable, rural residents happiness, is derived from micro-level household data. Incorporating data from disparate levels into a regression model can mitigate the interference of reverse causality on the estimated results. This is predicated on the notion that a rural resident's sentiment is unlikely to exert influence on the DVC. Therefore, the problem of omitted variable constitutes a potential endogeneity in the research. Factors such as rural residents' social networks, cultural custom, individual acceptance of the digital technology and the level of digital technology application, could all bear upon the sense of well-being among rural residents.

Given that the dependent variable of this article is ordinal, the *Conditional Mixed Process* (CMP) is utilized to further address selection biases arising from endogeneity, thereby describe the causal effect of DVC on rural residents happiness. Analogous to the instrumental variable estimation technique, the CMP approach necessitates the identification of plausible instrumental variables to alleviate the endogeneity concerns associated with DVC. A valid instrumental variable must satisfy two criteria: relevance and exogeneity. That is, the instrumental variable must correlate with the endogenous explanatory variable while not directly affecting the dependent variable.

Referring to the general practice of existing literature, this study adopts the interaction between the 2017 internet penetration rate and the number of landlines per hundred people from 1984 as an instrumental variable. The underlying rationale is that DVC are intertwined with the evolution of information and communication technologies, among which landlines were one of the early widespread means of communication. The abundance of landlines in a region is closely linked to its current internet development, which, in turn, bears upon the ongoing DVC. Hence, it is reasonable to posit a positive correlation between DVC and the number of regional landlines, meeting the relevance requirement for an instrumental variable. On the other hand, the quantity of landlines in a region is unlikely to exert a direct impact on rural residents happiness, thus satisfying the condition of exogeneity.

Table 4 presents the regression outcomes, wherein the F-statistic is 24.77, surpassing the empirical benchmark of 10 and thus rejecting the null hypothesis associated with a weak instrumental variable. In the initial stage of estimation, the instrumental variable—2017

TABLE 2 Baseline results.

Variables	Happiness	Happiness
Dig	0.0630*** (0.0119)	0.0471*** (0.0121)
Age		−0.0471*** (0.0057)
Gender		−0.0442* (0.0250)
Education		0.0262*** (0.0078)
Marriage		0.399*** (0.0376)
Health status		0.344*** (0.0268)
Employment		−0.0201 (0.0358)
Religious		−0.0110 (0.0692)
Social status		0.287*** (0.0133)
Family size		−0.00393 (0.0062)
Medical insurance		0.126*** (0.0485)
R ²	0.0009	0.0372
N	8,187	8,187

Robust standard error in parentheses, Statistical significance at the 1, 5, and 10% level is denoted by ***, **, and *, respectively.

TABLE 3 Robustness tests.

Variables	(1) OLS Model	(2) Alternative measure for the DVC	(3) Alternative measure for explained variable	(4) Add other control variables
Dig	0.0988*** (0.0246)	0.0473* (0.0283)	0.0635*** (0.0165)	0.0465*** (0.0121)
Controls	YES	YES	YES	YES
R ²	0.1363	0.0368	0.0802	0.0393
N	8,187	8,187	8,187	8,187

Robust standard error in parentheses, Statistical significance at the 1, 5, and 10% level is denoted by ***, **, and *, respectively.

internet penetration rate and the number of landlines per hundred people in 1984—correlates significantly and positively with DVC, corroborating the positive association between the chosen instrumental variable and the endogenous variable. The secondary phase of regression reveals that DVC has an effect size of 0.0981 on rural residents happiness, retaining significance at the 1% threshold. Accordingly, the estimations derived from the CMP methodology reinforce the assertion that DVC enhances rural residents well-being, indicating that the research conclusions of this article are robust.

5 Heterogeneity analysis

5.1 Different dimensions of DVC

In order to further explore the structural effects of DVC on rural residents happiness, this part compares and analyzes the impact of DVC on rural resident happiness from four sub dimensions including *rural digital infrastructure index*, *rural digital economy index*, *rural digital governance index* and *rural digital living index*. The results are shown in Table 5 for four sub-dimensions index. According to the coefficients, the *rural digital infrastructure index* and *rural digital economy index* have a significant positive impact on the rural residents well-being. The possible explanation is that the development of digital infrastructure and the digitalization of rural economy bring a lot of convenience to people's lives, such as transportation and logistics, financial services, health care, etc. Studies have shown that the opening of high-speed rail can affect rural poverty reduction, promote employment and income, improve consumption level, improve residents' health status, and thus improve rural resident happiness.

5.2 Individual characteristics of rural residents

The DVC may have varying impacts due to the individual characteristics of the different rural residents (Lindberg and Üden, 2010). This part selects the gender and age of the rural residents for further analysis, with the estimated results shown in column (1–2) of Table 6. The regression outcomes indicate that DVC has a more pronounced effect on the well-being of the male compared to females. The reasons that have a greater impact on the male group are as follows: First, men usually have more decision-making power in families and communities. Therefore, in the DVC, men may have a greater access to the use and benefits of new technologies. Second, men usually have more opportunities to receive formal education and technical training than women, which may lead them to be better able to take advantage of the opportunities brought by the DVC than

TABLE 4 CMP test.

First stage		Second stage	
IVs	0.4751*** (0.1583)	Dig	0.0981*** (0.0325)
F- statistic	24.77	Wald Test p-value	0.0115
Control variables	YES	Control variables	YES
R ²	0.1588	R ²	34.18
N	8,187	N	8,187

Robust standard error in parentheses, Statistical significance at the 1, 5, and 10% level is denoted by ***, **, and *, respectively.

women. Third, men's participation in the labor market is often higher. The improvement of agricultural production efficiency and market access by digital technologies directly affects men's careers more, thus enabling men to benefit more from the DVC.

The DVC exerts a significantly positive influence on the happiness of the middle-aged group, as opposed to the youth as shown in column (3)–(5) of Table 6. The reasons why the impact is significant on the middle-aged group but not so obvious on the young group are as follows: First, although the young group may be more familiar with and receptive to new technologies, the middle-aged group's acceptance and use of technology are often driven by practical needs and problem-solving. The technical services provided by DVC can help the middle-aged group solve practical problems, thereby generating more significant positive effects in their lives. Second, the middle-aged group may need more diverse information acquisition channels, including agricultural technology, market information, policy guidance, etc., and DVC can precisely provide such information services. While the young group are "digital natives," the new digital technologies bring less novelty to them and have a smaller marginal effect, so their influence is smaller.

5.3 Education status of rural residents

The impact of DVC on rural residents happiness may vary due to differences in educational attainment. Based on Jiang al. (2023), this part defines the education level below high school as "low education," and defines the education level above high school as "high education." The estimated results are shown in column (6)–(7) of Table 6. According to the regression results, the DVC has a significant positive impact on the happiness of the low education groups.

This is because residents with low education groups have lower cultural quality, less knowledge reserve and less learning ability than

TABLE 5 Different dimensions of DVC.

Variables	(1)	(2)	(3)	(4)
Rural digital infrastructure index	0.0195* (0.0116)			
Rural digital economy index		0.0450*** (0.0116)		
Rural digital governance index			0.00770 (0.0117)	
Rural digital living index				0.0167 (0.0116)
Control variable	YES	YES	YES	YES
R ²	0.0368	0.0372	0.0367	0.0368
N	8,187	8,187	8,187	8,187

Robust standard error in parentheses, Statistical significance at the 1, 5, and 10% level is denoted by ***, **, and *, respectively.

TABLE 6 Individual characteristics of rural residents.

Variables	(1) Female	(2) Male	(3) Youth	(4) Middle age	(5) Old man	(6) Low education	(7) High education
Dig	0.0316* (0.0187)	0.0582*** (0.0160)	0.00576 (0.0217)	0.0710*** (0.0187)	0.0481* (0.0240)	0.0503*** (0.0133)	0.0563* (0.0303)
Control variable	YES	YES	YES	YES	YES	YES	YES
R ²	0.0347	0.0400	0.0343	0.0426	0.0311	0.0371	0.0389
N	3,455	4,732	2,421	3,433	2,333	7,054	1,133

Robust standard error in parentheses, Statistical significance at the 1, 5, and 10% level is denoted by ***, **, and *, respectively.

those with high education groups. With the DVC, rural residents with low education groups have more channels to access digital technology, and can benefit more from it, which has a stronger role in improving their happiness. For the high-educated group who already enjoy a relatively high quality of life, the construction of digital countryside might only be one of the many conveniences they have already possessed, and thus its effect on enhancing their sense of happiness is rather limited. However, for the low-educated group, the same change might mean a huge leap from nothing to something, and thus their feelings would be more intense.

6 Mechanism analysis

Through the above analysis and tests, it is as shown that DVC plays a role in promoting rural residents' happiness, and this part verifies its mechanism.

6.1 Increasing income mechanism

DVC can bring more job opportunities and entrepreneurship platforms, and improve the income level of rural residents through innovative agricultural models, e-commerce and other means (Whitacre, 2008). Through the application of digital technology, rural residents can participate in the broader economy, education and job market, have the opportunity to obtain more resources and opportunities (Brooks, 2015), improve their economic and social status, reduce the gap between the rich and the poor, and thus improve their happiness (Jin and Xing, 2024). To verify this hypothesis, this part undertakes some tests. The results of the test are shown in column (1)–(3) of Table 7.

The column (1) presents the results of the baseline regression, while column (2) delineates the effects of DVC on rural residents'

income. The column (3) incorporates an intermediary variable -rural residents' income and explores its relationship with the DVC and rural residents' happiness. It is discernible that, upon the inclusion of the intermediary variable, the impact coefficient of DVC on rural residents' happiness diminishes slightly yet remains significant. Moreover, the effect of rural residents' income on their well-being is positively significant at the 1% level, indicating that income partially mediates the relationship between DVC and rural residents' happiness. This substantiates the theory that an increase in rural residents' income is one of the conduits through which DVC affects rural residents' well-being, thereby confirming hypothesis H2.

6.2 Reduced loneliness mechanism

In rural areas, rural residents mainly engage in agriculture as their daily occupation and the work is arduous. Moreover, they are far away from urban areas. There are fewer entertainment programs in rural areas, which makes them feel more lonely and their sense of happiness may be lower (Castellacci and Tveito, 2018). However, the development of DVC has broken through the limitations of time and space, enabling people in remote rural areas to achieve online connections with just one click, meeting their needs for making friends, communicating, interacting, entertaining, relaxing, shopping, etc., greatly satisfying their spiritual needs and enhancing their sense of happiness (Hong and Chang, 2020). Therefore, this part examines whether the digital village construction can enhance the sense of happiness of rural residents by reducing their sense of loneliness (Briggeman and Whitacre, 2010).

The results are shown in column (4)–(6) of Table 7. Column (4) is the baseline regression. In column (5), rural resident loneliness is presented as the explained variable, while the DVC serves as the explanatory variable. It can be seen that the DVC reduces the loneliness of rural residents. In column (6), incorporating rural

TABLE 7 Increasing income mechanism.

	(1) Happiness	(2) income	(3) Happiness	(4) Happiness	(5) Loneliness	(6) Happiness
Dig	0.0471*** (0.0121)	0.122*** (0.0099)	0.0436*** (0.0121)	0.0471*** (0.0121)	−0.0681*** (0.0143)	0.0386*** (0.0126)
Income / Loneliness			0.0560*** (0.0145)			−0.192*** (0.0182)
Control variables	YES	YES	YES	YES	YES	YES
R ²	0.0372	0.211	0.0378	0.0372	0.0428	0.0443
N	8,187	8,187	8,187	8,187	8,187	8,187

Robust standard error in parentheses, Statistical significance at the 1, 5, and 10% level is denoted by ***, **, and *, respectively.

resident loneliness, the effect coefficient of DVC on rural residents' happiness has decreased to some extent, yet it remains significant. The rural resident loneliness positively correlates with their happiness at the 1% significance level, suggesting that it plays a partial mediating role between DVC and rural residents' well-being. This supports the notion that reduce rural residents' loneliness may be one of the pathways through which the DVC influences rural residents' happiness, thereby confirming *H3*.

7 Conclusion

This paper examines the influence of DVC on rural residents' happiness. Through a comprehensive review of literature and theoretical analysis, the underlying mechanisms are dissected. Utilizing balanced two-phase panel micro-data from the CFPS and a digital village construction index, the *ordered probit model* is employed for empirical analysis. The findings are as follows: Firstly, the DVC augments the happiness of rural residents, a conclusion that retains its robustness subsequent to the adoption of alternative measurement for the dependent variables, independent variables and the CMP method. Secondly, a heterogeneity analysis reveals that DVC markedly enhances the well-being of male and middle-aged demographics, yet has a negligible effect on the younger cohort and does not significantly influence the happiness of rural residents with lower educational attainment. Thirdly, the mechanism test indicates that the DVC bolsters rural residents' happiness by amplifying their income and diminishing feelings of loneliness.

In light of the findings, this paper posits several policy recommendations:

Firstly, bolster investment and support for the digital rural landscape initiative. The government is urged to sustain its focus on the advancement of digital village projects, augmenting investment and support in areas such as digital infrastructure, e-commerce, telemedicine, and online education, with the aim of delivering more accessible, efficient, and superior digital services to rural residents to enhance their sense of well-being.

Secondly, tailor digital policies to accommodate diverse demographic segments. The research indicates that digital village initiatives significantly elevate the well-being of male and middle-aged cohorts, whereas their impact on younger and less educated groups is less pronounced. Hence, policy makers should be mindful of the distinct needs and characteristics of various segments when advancing digital rural development, and craft specialized digital policies to cater to the multifaceted demands of these populations.

Thirdly, prioritize the mental health of the rural populace. The government's commitment to addressing the mental health concerns of rural residents is critical. By organizing an array of cultural events, bolstering mental health education, and offering psychological counseling services, the government can aid rural residents in cultivating robust psychological frameworks, alleviating feelings of isolation, and enhancing their overall contentment.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee for Biomedical Sciences at Peking University (IRB00001052-14010). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MZ: Supervision, Writing – original draft, Writing – review & editing, Funding acquisition. YG: Data curation, Methodology, Software, Writing – original draft. HM: Project administration, Supervision, Writing – review & editing. YZ: Conceptualization, Methodology, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This research supported by the National Natural Science Foundation of China (72372093), the Humanities and Social Science Youth Project of the Ministry of Education (23YJC790213), the Science and Technology Strategy Research Project of Shanxi Province (202204031401102), Teaching Reform and Innovation Project of Higher Education Institutions in Shanxi Province (Project Number: J20240957) and the Research Start-up Fund of Taiyuan University of Science and Technology (TYUST SRIF: W20222004).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that Gen AI was used in the creation of this manuscript. The ideas, data processing, and composition of this paper were independently conducted by our team members. Due to limited

proficiency in English, we utilized translation software to polish and embellish the manuscript's expression.

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