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The Impact of Internet Use on Perception of the Poor–Rich Gap: Empirical Evidence from China

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Abstract: The advancement of Internet technology has provided a great impetus to alleviate poverty and promote economic progress. However, studies on the negative impact that the development of the Internet may have on individual perceptions are still rare. This paper uses data from the China Family Panel Studies (CFPS) in 2018 to construct multiple econometric models to empirically study the impact of Internet use (ITU) on the perception of the poor–rich gap (PPRG) and its mechanism in China. The instrumental variable (IV) model and Heckman model are used to solve potential endogenous problems. The research found that ITU has aggravated the PPRG of residents, and the test results are still robust after considering various endogenous sources. Additional analysis shows that the degree of dependence on the Internet is one of the transmission mechanisms of ITU on the impact of the PPRG, and its mediating effect accounts for 32.12% of the total effect. Another test result of the impact mechanism shows that the Internet media expands the reference group of residents through virtual areas and aggravates the PPRG of residents. Some test results from the perspective of heterogeneity show that: the effect of urban residents' ITU on PPRG is higher than that of rural residents. ITU of residents in economically developed areas has a significantly higher effect on the PPRG than residents in economically underdeveloped areas. The impact on ITU by residents of different age groups on aggravating the PPRG show an obvious increasing linear law. Our research provides an ITU interpretation path for the impact of PPRG from sociological theory and provides a new entry point for the impact of the Internet and subjective well-being.

Keywords: internet use; perception of the poor–rich gap; aggravating effect; subjective well-being; social equality; SDGs; China

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1. Introduction

Transforming our World: The 2030 Agenda for Sustainable Development covers 17 sustainable development goals (SDGs). Among the SDGs, SDG 10 clearly stated that we should reduce inequality within countries, so as to deal with the problem of increasing income inequality within countries and provide impetus for sustainable development [1]. In the context of rapid economic development, subjective welfare plays an increasingly important role in creating objective welfare, people's pursuit of well-being has changed from material to non-material. Individuals begin to pay more attention to subjective well-being rather than just the material standard of living. Numerous studies have shown that happiness is significantly reduced due to the widening poor–rich gap in the process of economic development [2–4]. The Internet, as technological innovation of great significance, has a potential impact on changes in income patterns and individual subjective perceptions [5–7]. In recent years, the Internet in countries represented by China has achieved rapid development. The Internet penetration rate has increased from 38.3% in 2011 to 70.4% in 2020 in China, and the number of Internet users has reached 989 million, of which the number of mobile Internet users is 986 million [8]. Mobile Internet has become an indispensable tool in

people's lives. Therefore, in the context of daily life becoming more and more inseparable from the Internet, paying attention to the impact of Internet use (ITU) on the perception of the poor–rich gap (PRPG) is of significance for discussing the subjective well-being of individuals and realizing the promotion of social equality and sustainable development as proposed by SDGs.

Information and communication technology (ICTs) has provided an important driving force for the economic growth of developing countries by improving innovation capabilities and increasing labor productivity [9,10]. Although ICTs have positive effects on economic growth in both developed and developing countries, ICTs have a greater positive effect on low-income and middle-income economies [11]. However, another study showed that developing countries' gains from ICT investment are significantly less than those of developed economies [12]. The impact of ICTs on inequality is also reflected in the differences between urban and rural areas. The development of ICTs may further widen the gap between developed and developing countries, but if the median and average income increase and poverty decrease, the increase in inequality can be tolerated to a certain extent [13]. However, studies have shown that the development of the Internet has a similar inverted "U-shaped" relationship to the urban–rural income gap. In the early stage of the development of the Internet, it was mainly considered that the use of the Internet in rural areas was weaker than that of urban residents, which widened the income gap between urban and rural areas. With the continuous popularization of the Internet, especially the development of the mobile Internet, the marginal effect of the Internet on the income growth of rural residents is higher than that of urban residents, which is conducive to narrowing the urban–rural income gap [14,15]. Therefore, at different stages of Internet development, the impact on the urban–rural gap is different, and this conclusion seems to apply to the Internet in developed and developing countries.

It is undeniable that the Internet has played an important role in alleviating poverty. The Internet alleviates the poverty of residents by improving the access to employment opportunities, financial accessibility, medical accessibility, education accessibility, and personal development capabilities [16–19]. A study shows that among ICTs indicators, ITU has the greatest impact on all poverty indicators. Promoting Internet penetration and expanding Internet access is important for poverty eradication [20]. Relevant studies in Mexico have confirmed that Internet access is an important mechanism for poverty reduction, but the poverty reduction effect of the Internet has different effects between rural and urban sectors, and the Internet poverty reduction effect in rural areas is more significant [21]. The development of the mobile Internet seems to provide greater positive effects for poverty reduction. Some research shows that mobile Internet coverage has a significant positive impact on household consumption and poverty reduction, policy formulation to promote investment in mobile Internet infrastructure can further promote poverty alleviation [22,23].

As a representative of digital technology, the Internet not only promotes economic development but also has positive significance for increasing human happiness [24,25]. For example, the Internet as a tool for social integration can accumulate social capital in the network to obtain new social support and obtain a happy experience from it [26,27], improving people's self-esteem, sense of belonging, and citizenship through ITU [28]. However, it is undeniable that the development of the Internet has also brought some negative effects. Some studies in psychology and sociology have confirmed that the use of the Internet by individuals reduces the communication between individuals and family members, reduces personal social interaction circles, and brings emotional depression and loneliness [29]. Similar conclusions such as the detrimental effects of ITU on subjective well-being are also supported by other studies [30–32]. The negative impact of the improper use of the Internet has also received attention. Some studies have confirmed that Internet addiction can cause adolescents to decrease their self-esteem, decrease their satisfaction with life and increase the risk of depression, and have a negative impact on their mental health [33,34].

The existing literature has fully discussed the economic effects brought about by the Internet. The popularization of the Internet provides a driving force for economic growth and poverty eradication. Although some documents also point out that the Internet may increase inequality [13,35], the Internet is still conducive to inclusive development from a long-term perspective [36,37]. At the same time, the existing literature has confirmed that ITU has both positive and negative effects on subjective perception. However, the issue of the impact of ITU on PPRG or the perception of inequality is rarely discussed in the existing literature. Taking PPRG as the starting point, discussing the impact of the Internet on subjective perception is of positive significance for improving people's livelihood policy formulation and subjective perception research.

This paper uses the microdata of China's household survey to construct an econometric model based on theoretical analysis to empirically study the impact of ITU on PPRG and attempts to answer the following key questions: (1) Does ITU affect individual PPRG? (2) What is the mechanism by which ITU affects PRRG? (3) From the perspective of urban–rural differences, different regions, and different ages, what is the difference in the impact of ITU on PPRG?

Based on the existing literature, The contribution of this paper is reflected in the following three aspects. First, this paper is one of the first studies focusing on the impact of the ITU on PPRG. By discussing some of the negative effects of the Internet on individual perceptions, in the context of the rapid development of the Internet, the literature on the relationship between Internet technology and social development has been enriched. Second, when studying the impact of ITU on PPRG, this paper fully considers the possible endogenous problems in the process of model building. The instrumental variable (IV) method, and the Heckman two-step method are used to solve the endogeneity problems caused by missing variables, measurement errors, and sample self-selection errors. Third, based on the reference group theory, this paper uses the mediating effect model and the moderating effect model to empirically verify the mechanism of ITU on the PPRG. At the same time, the paper also pays attention to the differences in the perceived impact of ITU on PPRG from urban, rural, regional, and age-related perspectives.

The remainder of this paper is structured as follows. Section 2 "Theoretical analysis and research hypothesis" section introduces the mechanism based on related theories to explain the effect of ITU on the PPRG. Section 3 "Measurement strategy" section introduces the measurement model used in the empirical study of this paper. Section 4 "Data sources, variables, and descriptive statistics" section introduces the data sources, variable settings, and basic descriptive statistics used in empirical research. Section 5 "Empirical results" section shows the test results of the econometric model. Section 6 "Conclusions and Discussion" section shows the conclusions of this paper and discusses them.

2. Theoretical Analysis and Research Hypothesis

2.1. The Social Interaction Area Expansion Effect of Internet Media

Before discussing the mechanism of the impact of ITU on PPRG, we must understand the expansion effect of social interaction areas brought about by the development of Internet media. The definition of truth at least partly depends on the nature of the media, that is to say, the media has an important impact on human cognition [38]. A community composed of individuals is a major form of grouping. The cognition of the group affects the cognition of the individual. At the same time, the cognition of the individual constitutes the cognition of the group. This is a two-way interactive effect called the endogenous interaction effect [39], also defined as the neighborhood effect.

As traditional media including newspapers, radio, television, etc., expand the scope of cognition based on the original reality area of the community, endogenous interaction effect has been expanded to a certain extent. However, due to the unidirectional and non-interactive (or low level of interactivity) of traditional media information transmission, the cognitive impact on individuals is limited. Therefore, the emergence of traditional media still has certain limitations in promoting the formation of individual cognition.

Internet media is different from traditional media. It is a digital and multimedia communication medium that mainly uses computers, mobile phones, and other mobile devices as terminals to disseminate information in the form of words, sounds, images, and videos, which have the characteristics of information interaction, that is, the two-way transmission of information flow [40,41]. This feature greatly improves the limitations of traditional media in the process of forming individual cognition. Internet media has created multiple social scenes in the virtual area. One or more virtual groups are formed among different individuals. In fact, the virtual group has most of the characteristics and functions of the social area of the community, and even the efficiency of information interaction exceeds the original reality area of the community. To a certain extent, the information interaction between individuals in the virtual area is wider than that in the reality area. As social media platforms (Facebook, Twitter, WeChat, etc.) rapidly and extensively expand social circles, individuals obtain far more information from others than they might realize [42].

Based on the above analysis, the relationship among the reality area of the community, the non-interactive virtual area constructed by traditional media, and the interactive area constructed by the Internet media are shown in Figure 1. The non-interactive virtual area uses traditional media as the information source to transmit information unidirectionally to individuals in the reality area, while the Internet media realizes the link between the reality area and the interactive virtual area. The Internet media exerts a social area expansion effect and expands the range of reference groups that form perceptions for individuals.

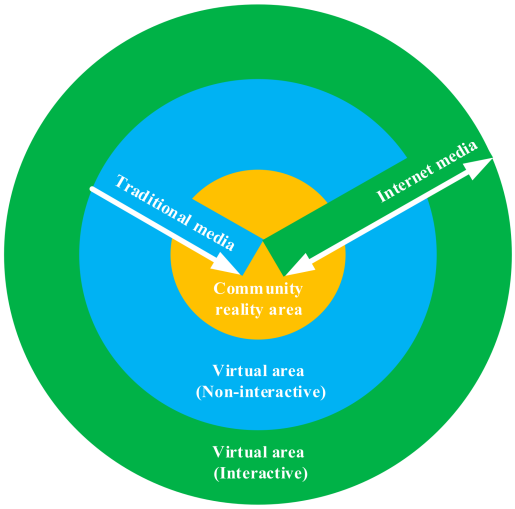

Figure 1. Schematic diagram of the virtual expansion effect of Internet media.

2.2. The Mechanism of the Impact of ITU on PPRG

The reference group theory in social psychology recognizes that the psychological subordinate group of individuals is a group recognized by individuals to establish and maintain various standards and provide a comparative framework. Individuals use the values and norms of their reference group as a benchmark for evaluating themselves and others, and as a basis for their social outlook and values [43]. There are two main functions of the reference group: on the one hand, the reference group plays a normative role in establishing a certain behavior standard to force individuals to follow; on the other hand, the reference group plays a comparative evaluation role in evaluating oneself or others as a comparison standard and starting point [44].

As a powerful technical tool, the Internet has a positive impact on an individual's cognition [45,46], which forms an individual's perception or behavior further. In such a process, we must note that the processing of information is the basis for cognition [47]. The degree of dependence on Internet access to information has strengthened the degree of trust in Internet information, which has an important and positive effect on the formation

of cognition. ITU strengthens an individual's trust in Internet information by strengthening the degree of dependence on the Internet, which has an impact on an individual's cognition further. As shown in the transmission path of "ITU-ITU dependence— PPRG (individual)" in Figure 2, the ITU has an impact on PPRG by strengthening Internet dependence.

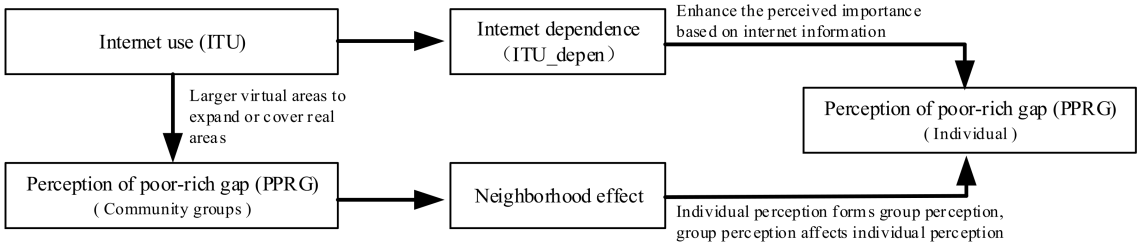

Figure 2. The mechanism of the impact of ITU on the PPRG.

According to the reference group theory, the reference group has a comparative evaluation function. The poor–rich gap reflects the income inequality between a group. However, for the individual, PPRG mainly comes from the cognition formed by the level of income in this group and the inherent cognition of the group. When the Internet was not popularized, PPRG mainly came from within the reality community. The rapid development of the Internet represented by the mobile Internet. The income level, consumption, and wealth of external groups in the community are widely disseminated through the Internet media in the form of text, pictures, or videos. These information form highly efficient interactions in the virtual area formed by the Internet media. The Internet expands the scope of reference groups through virtual areas, and the original reference groups for the PPRG have changed, thereby reconstructing the original group values and norms of residents. The "PPRG (Community groups)—Neighborhood effect— PPRG (Individual)" conduction path is shown in Figure 2. The ITU has an effect on the interaction process between community groups and individuals (the impact of community groups PPRG on an individual's PPRG) by expanding or covering the PPRG of the original group, thereby affecting individual PPRG. For example, through the Internet, individuals in poor areas see the life scenes of groups in economically developed areas, and individuals in economically developed areas see the life scenes of groups in poor areas, both of which have an impact on the PPRG of individuals.

Based on the above theoretical analysis, this paper puts forward the following hypotheses to be tested:

Hypothesis 1: *ITU has an aggravating effect on the PPRG of individuals. The more they use the Internet, the more individuals believe that the poor–rich gap becomes more serious.*

Hypothesis 2: *Internet dependence is one of the transmission mechanisms for ITU to PPRG. ITU increases the PPRG of individuals by increasing the Internet dependence of individuals.*

Hypothesis 3: *ITU exacerbates the PPRG of individuals by creating interactive virtual areas to expand individuals' reality area (community) reference groups.*

3. Measurement Strategy

3.1. Ordered Probit Model with Instrumental Variables (IV-Oprobit Model)

According to the data distribution characteristics of the explained variables studied in this paper, PPRG is perceived as a ranking variable with a value between 0 and 10, which meets the requirements of the Oprobit model for the data distribution characteristics of the explained variables. This model adopts the maximum likelihood estimation method for

estimation. However, it is estimated that the mathematical derivation process is no longer shown, and the equation form is shown in formula (1):

$$Y_i = F(\alpha_1 Inter_i + \alpha_{2r} Z_{ri} + \mu_i) \tag{1}$$

In the formula (1): Y_i represents the PPRG of the i-th resident, i = 1, 2, . . . , 22,305; $Inter_i$ represents ITU of the i-th resident; Z_{ri} represents the r-th control variable, r = 1, 2, . . . , 13; α_0, α_1 and α_{2r} represent the parameters to be estimated; μ_i represents the error term. $F(.)$ is a nonlinear function, the specific form is:

$$F(y_i) = \begin{cases} 1 & y_i < \delta_1 \\ 2 & \delta_1 < y_i < \delta_2 \\ \dots & \dots \\ j & y_i > \delta_{j-1} \end{cases} \tag{2}$$

In the formula (2), $\delta_1 < \delta_2 < \ldots < \delta_{j-1}$ are both tangent points and parameters to be estimated. Y_i is an unobservable continuous variable behind y_i, called a latent variable, which satisfies formula (3):

$$y_i = \alpha_1 Inter_i + \alpha_{2r} Z_{ri} + \mu_i \tag{3}$$

However, we were unable to collect all control variables that had an effect on PPRG, which is one of the sources of the endogeneity problem. Meanwhile, PPRG is a subjective measurement variable, and this data source characteristic may be subject to measurement error, which is the second source of endogeneity problem. To address both endogeneity problems, we refer to Wooldridge (2010) for setting the tool variables [48] and use the Oprobit model with instrumental variables, as shown in Equation (4).

$$\begin{cases} Inter_i = \omega_1 IV_i + \omega_{2r} Z_{ri} + \tau_i \\ y_i = \varsigma_1 Inter_i + \varsigma_{2r} Z_{ri} + \varsigma_3 Inter_i + \kappa_i \end{cases} \tag{4}$$

In formula (4), ω_1, ω_{2r}, ς_1, ς_{2r}, and ς_3 represent the parameters to be estimated; τ_i and κ_i represent the error term. IV_i represents the instrumental variable. $Inter_i$ represents the fitted value of $Inter_i$ extracted from the first line of formula (4).

3.2. Heckman Model

In addition to addressing the above two sources of endogeneity, we must also address a third source of endogeneity: self-selection bias. Whether residents use the Internet is not randomly distributed. Using the Oprobit model to test the impact of ITU on PPRG may bias the estimation results due to self-selection bias. To this end, this paper introduces two auxiliary variables: Internet use time (ITUT) and Internet use frequency (ITUF). On the one hand is the introduction of new variables to solve the problem of self-selection bias in ITU; on the other hand is the introduction of two new proxy variables that can characterize ITU and test the robustness of ITU impact on PPRG.

According to the Heckman model, this paper constructs a probability equation for ITU, the equation form is shown in formula (5) and the regression equation of the impact of ITUT and ITUF on PPRG, the equation form is shown in formula (6).

$$P_i = E(Y_i > 0) = \beta_r X_{ri} + \xi_i \tag{5}$$

In formula (5), P_i represents the probability of residents using the Internet; X_{ri} represents various observable explanatory variables that affect whether residents use the Internet. X_{ri} is the same as the variable contained in Z_{ri} in formula (1). ξ_i represents the error term, and other variables have the same meaning as formula (1). The inverse Mills ratio λ_i can be obtained by formula (6):

$$\lambda_i = \frac{\varphi(-X_{ri}\beta_r/\sigma)}{\phi(-X_{ri}\beta_r/\sigma)} \tag{6}$$

In formula (6), $\varphi(.)$ is the density function of the standard normal distribution; $\phi(.)$ is the density distribution function of the standard normal distribution, and σ is the standard deviation of the random error term ξ_i in the formula (5). The meaning of other variables is the same as formula (5). Furthermore, bring λ_i into formula (7):

$$Y_i = \delta_0 + \delta_1 Inter - A_i + \delta_{2r} Z_{ri} + \delta_3 \lambda_i + \psi_i \quad (7)$$

In formula (6), δ_0, δ_1, δ_{2r}, and δ_3 represent the parameters to be estimated, $Inter - A_i$ represents the auxiliary variables ITUT or ITUF. ψ_i is a random error term, and the meanings of other variables are consistent with formulas (1)–(6).

Of course, in order to simultaneously address missing variables, measurement error, and sample self-selection bias, we selected instrumental variables using the same approach, i.e., the mean value of the community ITUT was selected as an instrumental variable for ITUT and the mean value of the community ITUF was selected as an instrumental variable for ITUF.

4. Data Sources, Variables, and Descriptive Statistics

4.1. Data Sources

There are two sources of data used in this paper. The first source is the China Family Panel Study (CFPS) database implemented by the Institute of Social Science Survey (ISSS) at Peking University. CFPS focuses on the economic and non-economic well-being of Chinese residents, as well as on many research topics, including economic activity, educational attainment, family relationships and family dynamics, population migration, and health. It is a national, large-scale, multidisciplinary social tracking survey project [49]. The second source is the China Statistical Yearbook (2018) from which we obtained GDP per capita data for provincial administrative regions [50]. We performed the following data processing process: first, we merged the individual-level database, household-level database, and community-level database of CFPS using Stata 16.0 software; second, we eliminated the missing values and apparently problematic data in our selected variables; third, we merged the processed CFPS database with the per capita GDP data obtained from the China Statistical Yearbook GDP data from the Chinese Statistical Yearbook. The final result is a completely new dataset containing a sample of 22,305 individual residents from 30 provincial administrative regions and 2036 communities.

4.2. Variables, Definitions, and Descriptive Statistics

Explained variable: The PPRG is the explained variable of this paper, which represents the subjective perception of the poor–rich gap in China. The average value of the sample is 7.08, reflecting Chinese residents' belief that PPRG in China is relatively serious.

Explanatory variables: Whether the respondent uses the Internet is the core explanatory variable of this study, and its mean value reach of 0.49 is similar to the 53.7% of the year announced by the China Internet Network Information Center (CINIC) [8]. In order to solve the bias caused by selective endogeneity, this paper introduces the variables of ITUF and ITUT in the Heckman model. ITUF is an ordered variable of 1–7, the larger the value, the higher the frequency of ITU. ITUT is expressed by the time spent on the Internet per week, and the average online time of the sample is 13.66 h per week.

Control variables: This paper refers to the variable design of subjective perceptions such as happiness in the existing literature [25,51] and combines the actual needs of this article to control the variables from three aspects: individual characteristics, family characteristics, and socioeconomic environment characteristics. Individual characteristics include age, gender, education, health, etc.; family characteristics include lnincome per household, marriage, family size, etc.; socioeconomic environment characteristics include lnincome, lnpgdp, urban, etc. In order to reduce the estimation bias of the model, three regional control variables of eastern, central, and western have been set up with Northeast China as the reference area. The definitions and basic descriptive statistics of the above variables are shown in Table 1.

Table 1. Variables, definitions, and descriptive statistics.

Variables	N	Definitions	Mean (S.D.) [1]	Min	Max
PPRG	22,305	Perception of the poor–rich gap in China: from 0 = no serious to 10 = very serious	7.08 (2.41)	0	10
ITU	22,305	1 = using the Internet; 0 = not using the Internet	0.49 (0.50)	0	1
ITUF	10,987	Frequency of ITU: from 1 = never to 7 = every day [2]	4.23 (1.478)	1	7.4
ITUT	10,987	Time of ITU (hour/week)	13.66 (12.25)	0.1	120
ITU_depen	22,305	Respondents consider the importance of Internet information channels: from 1 = unimportant to 5 = very important	2.79 (1.64)	1	5
age	22,305	Age of the respondent (years)	48.92 (15.91)	16	95
gender	22,305	1 = male, 0 = female	0.50 (0.50)	0	1
education	22,305	Respondent's years of education	7.58 (5.04)	0	23
health	22,305	Self-reported health: from 1 = very healthy to 5 = very unhealthy	3.08 (1.22)	1	5
lnincome_per	22,305	Family net income per capita (logarithmic processing, yuan) [3]	9.62 (0.99)	6.91	11.94
marry	22,305	1 = married; 0 = other	0.82 (0.39)	0	1
familysize	22,305	Family size of respondent (person) [4]	4.16(2.02)	1	21
lnincome_com	22,305	Community average income of respondent (logarithmic processing, yuan)	9.88 (0.60)	6.91	11.94
urban	22,305	1 = respondent is located in urban, 0 = respondent is located in rural	0.50 (0.50)	0	1
lnpgdp	22,305	Per capita GDP of the provincial administrative region of respondent in 2017 (logarithmic processing, CNY 100 million)	10.9 (0.46)	10.29	12.07
eastern [5]	22,305	1 = respondent is located in eastern China region, 0 = otherwise	0.32 (0.47)	0	1
central	22,305	1 = respondent is located in central China region, 0 = otherwise	0.24 (0.43)	0	1
western	22,305	1 = respondent is located in western China region, 0 = otherwise	0.29 (0.46)	0	1

[1] S.D. refers to standard deviation. [2] Variable ITUF is the mean value of the frequency of using the Internet to study, work, socialize, entertain, and conduct business activities. [3] Yuan is the Chinese currency: 1 USD = CNY 6.53 in 2017 (Average value of the central parity of exchange rates for the whole year). [4] Variable family size does not include family members who eat in separate kitchens. [5] According to the classification method of the National Bureau of Statistics of China, the provincial administrative regions of mainland China are divided into eastern, central, western, and northeastern regions. The eastern part includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; the central part includes Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan; the western part includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang; the northeast part includes Liaoning, Jilin, and Heilongjiang.

5. Empirical Results

The benchmark model and instrumental variable model test results of the impact of ITU on the PPRG are shown in Table 2. Without adding any control variables, the test results of the impact of ITU on PPRG are shown in column (1) in Table 2. The test results show that ITU has a significant positive impact on PPRG at the 1% test level, indicating that the use of the Internet by Chinese residents has aggravate their perception of the severity of the poor–rich gap in China. This test result is still robust after gradually adding the control variables, as shown in the column (3) and column (4).

Aiming at the endogenous problems caused by missing control variables and subjective measurement errors, this paper uses the instrumental variable (IV) model to further strengthen the robustness of the impact of ITU on the PPRG in the benchmark model.

In this paper, we select community Internet penetration (the mean value of ITU in the community sample, ITU_mean) as an instrumental variable. First, the selection of ITU_mean as an instrumental variable for ITU is just identification, which meets the

requirement of instrumental variable selection. Second, we need to pay attention to the issue of exogeneity of instrumental variables, as the number of instrumental variables we selected did not exceed the number of endogenous variables (without creating over-identification) and could not be tested for exogeneity at the measurement level. ITU_mean, a variable measuring the development of the Internet in the community, has difficulty in having a direct impact on the PPRG of residents, but rather influences PPRG by affecting the ITU decisions of residents in the community. Finally, ITU_mean has an effect on ITU at the 1% significance level, indicating that there is no problem of weakly instrumental variables. Therefore, our choice of ITU_mean as an instrumental variable is largely consistent with the principle of binding exclusion.

Table 2. The impact of ITU on PPRG: benchmark model and IV model test results.

Variables	Benchmark Model: Oprobit			IV-Oprobit
	(1)	(2)	(3)	(4)
ITU	0.337 ***	0.188 ***	0.191 ***	0.322 ***
	(0.014)	(0.019)	(0.019)	(0.041)
age		−0.003 ***	−0.003 ***	−0.002 *
		(0.001)	(0.001)	(0.001)
gender		0.095 ***	0.102 ***	0.100 ***
		(0.014)	(0.014)	(0.014)
education		0.018 ***	0.015 ***	0.012 ***
		(0.002)	(0.002)	(0.002)
health		0.045 ***	0.047 ***	0.047 ***
		(0.006)	(0.006)	(0.006)
lnincome_per		0.013	0.017 *	0.011
		(0.010)	(0.010)	(0.010)
marry		0.074 ***	0.062 ***	0.059 ***
		(0.019)	(0.019)	(0.019)
familysize		−0.001	0.005	0.005
		(0.004)	(0.004)	(0.004)
lnincome_com		0.017	0.022	0.015
		(0.018)	(0.018)	(0.018)
lnpgdp		0.046 ***	−0.116 ***	−0.117 ***
		(0.018)	(0.029)	(0.029)
urban		0.019	0.019	0.014
		(0.016)	(0.016)	(0.016)
eastern			−0.019	−0.020
			(0.028)	(0.028)
central			−0.110 ***	−0.112 ***
			(0.024)	(0.024)
western			−0.279 ***	−0.281 ***
			(0.025)	(0.025)
N	22,305	22,305	22,305	22,305

Standard errors in parentheses. * $p < 0.15$ and *** $p < 0.01$. Stand In the first step of the IV-Oprobit model, ITU_mean has a significant positive effect on ITU at the 1% statistical level. Table 2 shows the results of the second step of the IV-Oprobit test only.

The instrumental variable model test result of IV-Oprobit is shown in columns (4). The IV Model test results still confirm the impact of ITU on PPRG in the benchmark model. We use the Stata16.0 software to calculate the marginal effect of the IV-Oprobit model test results in column (4) of Table 2. The marginal effect test results are shown in Table 3. When PPRG $\leq$ 8, ITU has a significant negative impact on PPRG, indicating that the use of the Internet weakens the residents' PPRG (scale of 0–8) in China. For example, using the Internet would reduce the probability of residents' perception that there is no poor–rich gap in China by 1.5% (PPRG = 0). However, when PPRG > 8, ITU has a significant positive impact on PPRG, indicating that using the Internet improves residents' PPRG (scale of 9–10) in China. For example, using the Internet increases the probability that residents perceive the poor–rich gap in China to be very bad (PPRG = 10) by 1.0%.

Table 3. The impact of ITU on PPRG: the Marginal effect of IV-Oprobit.

Variables	PPRG = 0	PPRG = 1	PPRG = 2	PPRG = 3	PPRG = 4	PPRG = 5
ITU	−0.015 ***	−0.004 ***	−0.008 ***	−0.015 ***	−0.013 ***	−0.015 ***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
N	22,305	22,305	22,305	22,305	22,305	22,305
Variables	**PPRG = 6**	**PPRG = 7**	**PPRG = 8**	**PPRG = 9**	**PPRG = 10**	**/**
ITU	−0.055 ***	−0.010 ***	−0.004 ***	0.016 ***	0.010 ***	/
	(0.007)	(0.001)	(0.001)	(0.002)	(0.001)	/
Control variables	Yes	Yes	Yes	Yes	Yes	/
N	22,305	22,305	22,305	22,305	22,305	/

Standard errors in parentheses. *** $p < 0.01$. Table 3 reports the marginal effect in column (4) of Table 2 and only reports the marginal effect of ITU on PPRG.

Furthermore, Table 2 also reports the test results of the effect of control variables on PPRG. Age at the 1% statistical level has a significant negative impact on PPRG in the benchmark test results. It shows that with the increase in age, the PPRG of residents gradually weakened. Judging from the test results of the impact of gender on PPRG, at a statistical level of 1%, it can be considered that males are more sensitive to PPRG than females, which also passes the significance test at the 1% statistical level in the IV model. The level of education aggravates PPRG, and both the benchmark model and the IV model pass the significance test at the 1% statistical level. Education has a positive impact on an individual's early cognitive development and adulthood cognition [52,53]. Therefore, the higher the level of education, the more sensitive the cognition of the poor–rich gap. Self-reported health has a significant positive impact on PPRG, which shows that the worse the self-reported health of residents, the higher the PPRG. This may be related to the inequality of China's medical resources and the intuition that residents cannot get high-quality medical resources. The uneasy feeling of unhealthiness increases residents' perception of the unfair distribution of medical resources in the process of medical treatment and aggravates their PPRG. Residents who are married are more sensitive to PPRG. The economic pressure of raising children and supporting parents in daily life exacerbates their PPRG. The IV-Oprobit model test results show that the PPRG for married residents is significantly higher than that of residents with other marital statuses at the 1% statistical level. The stronger the economy of the region where the residents live, the weaker the PPRG of the residents. The positive effect of absolute income growth due to the macroeconomy of the region masks the negative effect of residents' perceptions of relative income disparity. This conclusion passed the test at the statistical level of 1% in both the benchmark model and the IV model that control regional variables.

Through the establishment of the IV model, some of the errors caused by the endogeneity of missing variables and subjective measurement errors have been solved. However, the bias caused by self-selection bias in ITU has not been considered. To this end, we established the Heckman two-step method by introducing the two auxiliary variables of ITUT and ITUF to solve the self-selection bias of ITU samples and further test the robustness of ITU's impact on the PPRG.

Columns (1) and (2) of Table 4, respectively, report the results of the second step of the Heckman two-step method using ITUT and ITUF. The test results show that both ITUT and ITUF pass the significance test at the statistical level of 1%. The Mills lambda test values all passed the test at a significance level of 1%, indicating that there is indeed a problem of self-selection bias in ITU under the full sample condition, and it is necessary to adopt the Heckman model.

We also draw on the same method of selecting instrumental variable ITU_mean for ITU. The IV-Heckman model was established by introducing community ITUT (ITUT mean of the sample within the community, ITUT_mean) and community ITUF (ITUF mean of the

sample within the community, ITUF_mean) as the instrumental variables of ITUT and ITUF, respectively, considering the endogeneity problems caused by measurement deviation, missing variables, and self-selection bias. Columns (3) and (4) of Table 4 report the test results of the IV-Heckman model. The test results still support test results of Heckman Model. ITU has a significant positive impact on the PPRG, that is, ITU exacerbates the PPRG of residents.

Table 4. The impact of ITU on PPRG considering the endogeneity of sample self-selection: Heckman model and IV-Heckman test results.

Variables	Heckman Model		IV-Heckman Model	
	(1)	(2)	(3)	(4)
ITUT	0.008 ***		0.011 ***	
	(0.002)		(0.002)	
ITUF		0.095 ***		0.180 ***
		(0.017)		(0.038)
Control variables	Yes	Yes	Yes	Yes
Mills lambda	−0.502 ***	−0.535 ***	−0.243 ***	−0.269 ***
	(0.146)	(0.146)	(0.072)	(0.071)
N	10,987	10,987	10,987	10,987

Standard errors in parentheses. *** $p < 0.01$. Only show the results of the second step of the Heckman two-step method. The selected instrumental variables do not have weak instrumental variables problem. ITUT_mean has a significant positive effect on ITUT at the 1% statistical level. ITUF_mean has a significant positive effect on ITUF at the 1% statistical level.

This paper also conducts a further analysis from the heterogeneity perspective of urban-rural differences, regional differences, and age differences.

Urban and rural heterogeneity: Columns (1) and (2) in Table 5, respectively, report the impact of ITU in urban and rural areas on PPRG using IV-Oprobit model. The test results show that, whether in urban or rural areas, ITU has significantly increased the PPRG of residents. Columns (3) and (4) report the marginal effects of the IV-Oprobit model. The test results show that there are significant differences between urban and rural areas. Using the Internet increases urban residents' PPRG by 11.3%. While for rural residents, it only increased PPRG by 7.4% (based on calculated results of the marginal effect when PPRG = 10). With the continuous advancement of China's urban–rural integration process, Internet barriers in rural areas have gradually disappeared, and Internet accessibility has greatly improved. However, the application scenarios of the Internet still lag in rural areas. More abundant Internet application scenarios may be the entry point to explain the differences between urban and rural areas.

Table 5. Urban and rural heterogeneity: test results of the impact of ITU on the PPRG.

Variables	IV-Oprobit Model		Marginal Effect (PPRG = 10)	
	(1)	(2)	(3)	(4)
	Urban	Rural	Urban	Rural
ITU	0.208 ***	0.171 ***	0.113 ***	0.074 ***
	(0.027)	(0.027)	(0.016)	(0.020)
Control variables	Yes	Yes	Yes	Yes
N	11,220	11,085	11,220	11,085

Standard errors in parentheses. *** $p < 0.01$.

Regional heterogeneity: Columns (1)–(4) in Table 6, respectively, report the impact of ITU on the PPRG in the eastern, central, western, and northeastern regions of China using the IV-Oprobit model. The test results show that, regardless of the region, ITU has significantly increased the PPRG of residents. However, from the test results of the marginal effects of the IV-Oprobit model in columns (5)–(8), it is found that there are differences in the degree of impact of ITU on PPRG in different regions, which is specifically reflected in:

the impact of ITU on the PPRG deepened successively in the northeastern, western, eastern, and central regions (based on calculated results of the marginal effect when PPRG = 10). The economic development of the northeast and western regions is relatively backward compared with other regions in China. The Internet penetration rate in the northeastern and western regions is lower than that in the eastern and central regions, and the Internet application scenarios are still incomplete, especially in rural areas (this can be reflected in the test results of urban–rural heterogeneity). ITU reconstructs the social values and normative perceptions of the residents relying heavily on rich Internet application scenarios. Therefore, ITU has a higher exacerbating effect on the PPRG of residents in developed regions than in less developed regions.

Table 6. Regional heterogeneity: test results of the impact of ITU on the PPRG.

Variables	IV-Oprobit Model				Marginal Effect (PPRG = 10)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Eastern	Central	Western	Northeast	Eastern	Central	Western	Northeast
ITU	0.224 ***	0.178 ***	0.163 ***	0.219 ***	0.095 ***	0.126 ***	0.078 ***	0.073 *
	(0.035)	(0.039)	(0.034)	(0.050)	(0.022)	(0.026)	(0.021)	(0.040)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	7155	5460	6552	3138	7155	5460	6552	3138

Standard errors in parentheses. * $p < 0.1$ and *** $p < 0.01$.

Age heterogeneity: Columns (1)–(4) in Table 7 report the impact of ITU on PPRG from the perspective of different ages using the IV-Oprobit model. The test results show that the impact of ITU on PPRG in the 16–30-year-old group did not pass the significance test. In addition to other age groups, ITU exerts a positive aggravating effect on PPRG at the 1% significance level. The marginal effect of the IV-Oprobit model test results reported in columns (5)–(8) show the impact of ITU on PPRG. The test results show that with the increase in age, the impact of ITU on PPRG is gradually intensified. The probability of using the Internet for 30–50-year-old, 50–70-year-old, and 70–95-year-old groups increases PPRG = 10 by 9.1%, 11.8%, and 18%, respectively. Older groups have long established reference groups based on their own life circles (community scope) or traditional media, and the Internet has brought great changes between reference groups and original reference groups. It will have a more severe impact on the original reference group established by this group than the younger group. Older groups have long established reference groups based on their circle of life (community-wide) or traditional media. The intervention of the Internet has reconfigured the reference groups of aging groups. Compared with younger groups, the Internet has brought a more severe impact on the PPRG of older groups. The main reason is that at the early stage of rapid development of the Internet, older groups had difficulty in distinguishing the authenticity of Internet information and tended to trust all information on the Internet. However, a lot of information on the Internet is false and exaggerated.

Table 7. Age heterogeneity: test results of the impact of ITU on PPRG.

Variables	IV-Oprobit Model				Marginal Effect (PPRG = 10)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	[16, 30]	[30, 50]	[50, 70]	[70, 95]	[16, 30]	[30, 50]	[50, 70]	[70, 95]
ITU	0.196	0.286 ***	0.382 ***	0.693 ***	0.057	0.091 ***	0.118 ***	0.180 ***
	(0.133)	(0.060)	(0.082)	(0.207)	(0.039)	(0.019)	(0.025)	(0.053)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3589	8008	8796	1912	3589	8008	8796	1912

Standard errors in parentheses. *** $p < 0.01$. The minimum age of the resident sample is 16 years old and the highest is 95 years old. The age group includes the lower limit, but both the 95-year-old and 70-year-old samples were included in the 70–95 age range.

Through the above analysis, ITU has a significant aggravating effect on PPRG, and Hypothesis 1 has been verified. Furthermore, we analyze the mechanism of ITU's impact on PPRG and further verify Hypothesis 2 and Hypothesis 3 proposed in the theoretical analysis.

Constructing an intermediary effect model to analyze the transmission mechanism between ITU and PPRG: According to the theoretical analysis, the degree of residents' dependence on Internet information channels may be a transmission mechanism of the impact of ITU on the PPRG. Columns (1)–(3) in Table 8 use the Oprobit model to test whether ITU_depen is a transmission mechanism of the ITU on the perception of the wealth gap, that is, whether ITU_depen is an intermediary variable. The test results show that ITU has a significant positive impact on PPRG. This result is consistent with all previous model test results. At the same time, ITU has a significant positive effect on ITU_depen at a statistical level of 1%, and ITU_depen also plays a positive impact on PPRG. Therefore, it can be considered that ITU further aggravates the PPRG of residents by increasing the residents' reliance on Internet information. Furthermore, it is shown by calculation that the intermediary effect played by ITU_depen in the process of perceived impact of ITU on PPRG accounts for 32.12% of the total effect, which further proves that ITU_depen is an important transmission mechanism (based on calculated results of the marginal effect when PPRG = 10). Therefore, Hypothesis 2 is verified.

Table 8. Test results of the mediating effect of ITU_depen.

Variables	Oprobit Model		
	(1)	(2)	(3)
	PPRG	Inter_Depen	PPRG
ITU	0.191 ***	1.203 ***	0.115 ***
	(0.019)	(0.021)	(0.021)
ITU_depen			0.051 ***
			(0.006)
Control variables	Yes	Yes	Yes
N	22,305	22,305	22,305

Standard errors in parentheses. *** $p < 0.01$.

In the theoretical analysis, based on the reference group theory, this paper proposes the Internet as a new medium to expand the reality area of residents with virtual areas. The virtual area expands the reference group and is no longer limited to the community where the residents live. Therefore, this paper uses the average value of PPRG in the community other than the residents themselves to represent the reality area and set it as an explanatory variable (Mean_PPRG), which uses ITU as the moderating variable and PPRG as the explained variable to establish a moderating effect model to test whether the Internet has expanded the reference group of residents and aggravated the transmission mechanism of PPRG. Columns (1) and (2) in Table 9 report the test results using the Oprobit model and the IV-Oprobit model. The test results of the two models both show that at a statistical level of 1%, Mean_PPRG has a significant positive impact on PPRG, and ITU also has a significant positive impact on PPRG. At the same time, the interaction term (Mean_PPRG * ITU) exerts a significant negative impact on PPRG. Therefore, while ITU exacerbates PPRG, it plays a negative role in mediating the impact of Mean_PPRG on PPRG.

Furthermore, we discuss whether the use of the Internet has expanded the reference group of residents with virtual areas through the test results of columns (3) and (4) in Table 9. Taking the test result of marginal effect of Oprobit model in column (3) as an example, ITU has an aggravating effect on PPRG to 0.072, which is much higher than the negative effect of Mean_PPRG * ITU's impact on PPRG to 0.026. It can be considered that although the virtual area brought by the Internet has partially replaced the reality area, the virtual area brought by the Internet together with the original reality area has realized the expansion of the reference group of residents. In this way, the net effect of ITU on PPRG is 0.046. In the Marginal effect of IV-Orpobit model shown in column (4), the net effect of ITU

through expanding the reference group after the endogeneity is resolved is 0.037, and the robustness of this conclusion is verified (based on calculated results of the marginal effect when PPRG = 10). Therefore, Hypothesis 3 is verified.

Table 9. Test results of the mediating effect of ITU on PPRG.

Variables	Orpobit Model	IV-Orpobit Model	Marginal Effect (PPRG = 10)	
	(1)	(2)	(3)	(4)
Mean_PPRG	0.182 ***	0.250 ***	0.055 ***	0.076 ***
	(0.019)	(0.044)	(0.006)	(0.013)
ITU	0.236 ***	0.264 ***	0.072 ***	0.080 ***
	(0.013)	(0.019)	(0.004)	(0.006)
Mean_PPRG * ITU	−0.085 ***	−0.143 ***	−0.026 ***	−0.043 ***
	(0.018)	(0.031)	(0.005)	(0.009)
Control variables	Yes	Yes	Yes	Yes
N	21,458	21,458	21,458	21,458

Standard errors in parentheses. *** $p < 0.01$.

6. Conclusions and Discussion

6.1. Conclusions

The development of the Internet has brought many positive effects, including promoting economic growth, increasing residents' chances of earning income, and contributing to poverty alleviation. These large amounts of literature have been discussed and studied. However, the negative impact that the Internet may have on individual perceptions of residents is rarely involved. This paper empirically studies the impact of ITU on the PPRG of residents and its mechanism by constructing an econometric model. Based on the full text analysis, the following brief conclusions can be drawn:

Firstly, we found that ITU has increased the PPRG of residents. In China, residents who use the Internet believe that PPRG in China is worse than those who do not. After constructing the IV model, Heckman model, and IV-Heckman model to solve the endogenous problems caused by missing variables—measurement bias and sample self-selection—the above test results are still robust.

Secondly, there are obvious differences in the impact of ITU on PPRG in the perspective of urban and rural heterogeneity, regional heterogeneity, and age heterogeneity. Overall, the significance test is passed regardless of the sub-sample. The aggravating effect of urban residents' ITU on PPRG is higher than that of rural residents. The aggravating effect of ITU by residents in economically developed areas on PPRG is significantly higher than that of residents in underdeveloped areas. The aggravating impact of ITU by residents at different age (except the 16–30-year-old group) on PPRG shows a clear linear increase law. Internet use by the 16–30-year-old group did not have a significant impact on PPRG.

Third, we further studied the mechanism of the impact of ITU on PPRG. The study found that the degree of dependence on Internet information is one of the transmission mechanisms of the impact of ITU on PPRG. The test results of the mediating effect model show a significance level of 1%; the mediating effect played by the degree of dependence on Internet information accounts for 32.12% of the total effect.

Fourth, the Internet plays the role of a new interactive medium, expanding the reference group of residents through virtual areas and exacerbating residents' PPRG. By constructing a moderating effect model, the moderating effect of ITU in the process of the impact of PPRG_mean on PPRG among residents was tested. In the test results of the mediation effect model with instrumental variables, the use of the Internet exerted the effect of increasing PPRG at 0.080, while weakening the impact of PPRG_mean on PPRG. However, there is a net increase effect of residents' ITU by expanding the residents' reference group's PPRG to 0.037.

6.2. Discussion

The Internet, as a technology embedded in economic and social development, has a positive impact on the promotion of social equality proposed by SDGs. The positive impact of Internet development on objective welfare, including the objective poverty gap and income level, has been fully discussed. At the same time, it has also been discussed that the digital divide may generate new social exclusion [54]. However, we must realize that the positive effect of subjective well-being in the creation of objective well-being cannot be ignored. A positive attitude and a high level of subjective well-being has positive effects on the creation of objective well-being. Therefore, our research explores the impact of Internet development on subjective well-being from the perspective of reference group changes, that is, to explore two main topics: what impact does ITU have on PPRG and how does ITU affect PPRG? It provides an explanation path of ITU's impact on PPRG from the perspective of sociological theory.

Therefore, our research provides a new entry point and idea for the study of the impact of the Internet on subjective well-being. The double-edged sword of Internet development is not only reflected in the creation process of objective welfare (improving the overall income level but expanding income gap), and it is also reflected in the creation of subjective well-being (improving the overall sense of well-being but increasing PPRG). We must realize that the impact of the Internet on economic and social development is comprehensive, complex, and multi-layered, which requires further joint discussions among multiple disciplines such as economics, management, and sociology.

Based on the reference group theory, this paper analyzes PPRG by the Internet and its mechanism of action by constructing an Oprobit model. In the process of empirical analysis, the instrumental variable model, Heckman model, and IV-Heckman model are used for robustness testing, aiming to solve the endogeneity problems caused by missing variables, measurement errors, and sample self-selection. It also analyzes the impact of ITU on the PPRG of residents under the perspective of urban and rural, regional, and age heterogeneity. Furthermore, ITU_depen is used as a mediating variable to establish a mediating effect test model and ITU as a moderating variable to establish a moderating effect model to discuss the mechanism of ITU on PPRG. All empirical results verify the aggravating effect of ITU on the PPRG of residents. Our research findings further illustrate that Internet development is not only a "double-edged sword" at the objective level, but also has negative impacts at the subjective level.

China is in a process of dramatic social change and any technological development will have certain negative effects. Against the backdrop of Internet penetration and the development of the new "Internet+" business model, this paper takes China, a large developing country with a large population, as the research object, and concludes through an empirical model that ITU has an exacerbating effect on PPRG among residents, which has certain policy implications for Internet development worldwide. On the one hand, subjective perception is necessarily generated from the existence of an objective wealth gap. The financial departments of each country need to further optimize fiscal and taxation policies, improve the income distribution system, and gradually reduce the objective wealth gap, and various world organizations (such as the United Nations, World Bank, etc.) should work to gradually eliminate the income gap between countries and make efforts to achieve the elimination of inequality between countries in accordance with SDGs. On the other hand, the development of the Internet has promoted the communication efficiency and visualization of information, and the capital-driven "traffic economy" has led to the flooding of the Internet with some spam and false information. This requires advanced artificial intelligence technology to filter and shield undesirable information such as spam and malicious information on the Internet, so as to alleviate the negative impact of the Internet at the subjective level and further improve residents' sense of well-being.

However, this paper still has certain limitations. On the one hand, although we have discussed the two potential impact mechanisms of ITU on PPRG, there are still other potential mechanisms that have not been taken into consideration. On the other hand, due

to the limitations of the database, metrology technology, and the stage of development of the Internet in China, this paper is mainly based on CFPS2018 cross-section data, and it is impossible to consider the continuous impact of ITU on the PPRG of individuals in the time series. Although only cross-sectional data is used, the test results of different measurement models in this paper can be mutually verified and can support the conclusions of this paper. The relevant findings of this research provide new inspiration for the impact of the Internet on the subjective perception of individuals, especially the potential negative effects that may be brought about using the Internet. Extending the data to panel data and discussing more impact mechanisms of ITU on PPRG is the focus of the next step of research.

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