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Does Rural Population Hollowing Bring a Loss in Happiness?

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Abstract

Based on the survey of 4969 households from 336 villages in 22 provinces and the Chinese General Social Survey (CGSS), this paper finds that the rural residents' happiness does not decline significantly under the background of population hollowing in rural China. Empirical research finds that (i) there is an inverted U-shaped relationship between the degree of population hollowing and the happiness of rural residents, almost 80% investigated villages' population hollowing are less than the optimal value, therefore, the increase of rural population hollowing will not cause the loss of happiness within a short term. (ii) Population hollowing brings an increase of income level which improves resident's happiness, and negatively affects happiness through the left-behind problems, lack of culture and rural democracy, the positive effect is gradually weakened and the negative effect is gradually strengthened. (iii) Population hollowing has no effect on the residents with lower happiness level, while the rural residents with higher happiness are more sensitive to it. (iv) The inverted U-shaped curve is significant in the elderly, high-income, healthy and married groups, but not in the low-income, unhealthy and unmarried groups. The above findings are conducive to an objective and rational understanding of the impact of the hollowing of rural population accompanying China's rapid urbanization on the welfare of rural residents.

Key Words: population hollowing, happiness, inverted U-shaped relationship

1. Introduction

The phenomenon by which the working-age population migrates out of rural areas and into urban areas, thus leaving children and elderly people behind, is known as population “hollowing.” This transfer of labor from rural to urban areas has provided a powerful driving force behind China’s recent years of urbanization and economic growth (Li, 2004; Chen and Song, 2014), however, it has also led to a substantial loss of the population in rural areas. Despite the economic benefits, population hollowing is one of the core problems affecting rural areas in China, being listed as one of the new “three rural issue” by some Chinese scholars. According to the China National Bureau of Statistics, the number of residents per village has showed a steady decreasing trend from 1136.6 in 2001 to 1038.7 in 2015. These data show that population hollowing has occurred in China’s rural areas, and one might reasonably extrapolate that the same trend will continue in the future. Given this backdrop, we discuss the impact of rural population hollowing on the happiness of rural residents given China’s rapid urbanization, and explain why happiness does not decline in the context of population hollowing.

Given the widespread hollowing out of the rural population, many literatures have discussed concern regarding the welfare of (remaining) rural residents. To most observers, life for left-behind villagers is miserable given the relatively low living standards frequently found in the countryside. Population hollowing aggravates the aging population of rural areas, children, the elderly and women bear heavy physical and mental pressure in nearly all areas of life (Chang *et al.*, 2011; Wen and Lin, 2012; Wu and Ye, 2016; Lu *et al.*, 2016; Ao *et al.*, 2016). These left-behind individuals are unable to shoulder the heavy responsibility of modern agriculture and rural governance, especially affecting the smooth implementation of village democracy. One potential implication of the above observations is that population hollowing will lead to a sharp decrease in the life satisfaction or happiness of rural residents.

Is there really a sharp decline in the happiness of rural residents? Our survey’s answer is no, the happiness of rural residents has not decreased significantly. From 2011 to 2017, the team led by the author surveyed rural China six times and a representative database was collected. The database consists of data from 4,969 rural residents in 336 villages in 112 counties in 22 provinces. A measure of happiness was obtained by asking “If you evaluate how happy you were last year, how many points can you score”, with options of response including “very unhappy” scored as 1 and going up to 10 indicating “very happy.” The average happiness from 2011 to 2016 was 6.8, 7.2, 7.6, 7.8, 7.2 and 8.1, respectively, which shows a generally increasing trend (see figure 1), except for the decline in 2015. In other words, under the background of population hollowing, the happiness of rural residents did not decline significantly as most observers may expect. Data from Chinese General Social Survey (CGSS) database also supports that the happiness of rural residents did not decline (see figure 2). The CGSS asked respondents “overall, do you think your life is happy”, 1 for “very unhappy” to 5 for “very happy”¹. More interestingly, despite the large income gap between urban and rural residents, the happiness of rural residents is slightly lower than that of urban residents. Knight and Gunatilaka (2010) also found that despite the large income gap between urban and rural residents in China, the happiness gap between urban and rural residents is relatively small.

¹ There are slight differences in the question settings of the happiness survey in different years. For example, in the 2005 survey, the question was: how do you feel about your life in general? You feel your life is: very unhappy -1; Unhappy -2; General - 3; Happiness - 4; Very happy -5.

Why does the deepening of the population hollowing not bring the sharp decline in the happiness of rural residents as expected? In order to explain this question, we propose a complete theoretical framework. We believe that the population hollowing will affect happiness through five channels, including an income effect, environmental improvement effect, the “left-behind” problem, a lack of culture, and the weakening of rural democracy. Migrant workers can increase their income significantly compared to their earnings had they stayed in the village, and so a higher population hollowing in the villages correlates with a higher income level which has a positive effect on happiness. Yet, the effect of income on happiness is marked by diminishing margins. As income increases, the positive effect on happiness will become smaller and smaller. Environmental improvement effect means that the reduction of the population will alleviate ecological environmental pressures from overpopulation and lack of quality infrastructure, which leads to an improvement in the living environment of remaining residents; this also has a positive impact on happiness. Yet, the environmental improvement effect is hard to show in the short term as these improvements occur gradually. With the increase of population loss, the left-behind problem gradually becomes more prominent such as the health of the elderly, children’s education, women’s solitary life without husbands – all of which lead to social instability and thus have a negative impact on happiness. Beyond that, the outflow of labor makes rural cultural activities and democracy difficult to be carried out effectively, hindering the improvement of happiness. The total effect of population hollowing on happiness depends on the magnitude of these positive and negative effects.

Our theoretical analysis suggests that there is an inverted U-shaped curve between the degree of population hollowing and the happiness of rural residents. For those villages with a low degree of population hollowing, migrant workers’ additional income will greatly increase income levels in the village. Due to the small number of migrant workers, there is still abundant labor in the village so that the impact of the left-behind problem, the lack of culture, and the weakening of rural democracy is likely to be relatively small-beer. Therefore, the positive effect dominated by income effect is larger than the negative effect, and population hollowing will increase the happiness of rural residents. However, villages with a high degree of population hollowing have the exact opposite situation. The negative effects including left-behind problem, the lack of culture, and the weakening of rural democracy are prominent increasingly with the massive outflow of population. At the same time, the effect of the income increase on happiness is getting smaller and smaller because of the law of diminishing marginal returns. In addition, the long-term environmental effects make the negative effect far greater than the positive effect. Thus, in this case population hollowing leads to a loss in happiness. Therefore, there is an inverted U-shaped curve between the degree of population hollowing and the happiness of rural residents. A certain degree of population hollowing will have a positive impact on happiness. After exceeding the optimal value, hollowing will bring a loss in happiness to rural residents. Thus, there is a “happy turning point” between the two stages.

Our theory can explain the problems mentioned above well. According to our theory, in the process of urbanization, a certain degree of population hollowing will have a positive impact on happiness of rural residents, it can only lead a loss in happiness when the degree of population hollowing exceeds the "Happiness Inflection Point". For China now, the population hollowing degree of most villages has not reached the optimal value, but a substantial amount, which is why we cannot observe the trend of declining happiness of rural residents in the context of deepening

population hollowing.

Empirical research confirms our theory and explanation. Based on the data of 4451 households in 298 villages from the database mentioned above, using a model with a quadratic term, we find there is a significant and robust inverted U-shaped relationship between the degree of population hollowing and the happiness of rural residents. Almost 80 percent of the investigated villages' population hollowing is less than the optimal degree of population hollowing corresponding to the "Happiness Inflection Point", so that the increase in the rural population hollowing will not cause a loss of happiness within a short period of time.

This paper also verifies the mechanism in the theoretical framework by using Structural Equation Models. We find that the hollowing of rural population improves residents' happiness by increasing the village income level, and negatively affects residents' happiness by affecting left-behind issues. In addition, the population hollowing is not conducive to cultural activities and villagers' self-governance, and thus restraining the improvement of happiness. However, the income effect will not be significant when the population hollowing degree reaches a certain level, and the mediating effect of left-behind problem is only existing for villages with high degree of population hollowing. In other words, with the increase of population hollowing, the positive effect will become smaller, while the negative effect will become larger. Therefore, the influence of the hollowing of rural population on the happiness presents an inverted U-shaped curve. Empirical results are consistent with the theoretical framework.

Different from previous studies which focuses on the happiness of migrants, such as Barcus(2004), Wright(2010) and Chu and Hail(2014), we examine the impact of rural-urban migrants on the welfare of left-behind people at the village level. Our analysis includes different levels of impact rather than a single mediating influence. As can be seen from the introduction above, we consider economic, political, social, environmental, cultural influences. Our research helps us to understand the impact of the rural population hollowing on rural residents' welfare, also shedding light on another avenue through which urbanization has impacted the welfare of rural residents. The problem of population hollowing may not only exist in the process of urbanization in China, but also in the context of other developing countries. Our research can provide a precedent for the study of the welfare of rural residents in other developing countries.

The paper unfolds as follows. In section 2, I set out the theoretical framework, and explain the inverted U-shaped relationship between population hollowing and happiness. Section 3 tests the inverted U-shaped curve, and discusses results. Section 4 explores whether there are positive and negative mechanisms proposed by the theory. The heterogeneity research is presented in Section 5. And the last section concludes.

2. Theoretical framework

2.1 How does population hollowing affect happiness of rural resident?

We believe that population hollowing will affect happiness of rural resident from five aspects, including income effect, environmental improvement effect, left-behind problem, a lack of culture and rural democracy weakening effect. Among them, income effect and environmental improvement effect have positive effects on happiness, while others have negative effects.

Income Effect. A lot of literature has explored the relationship between income growth and happiness (Easterlin, 1995; Di Tella *et al.*, 2003; Alesina *et al.*, 2004; Leigh and Wolfers, 2006; Clark *et al.*, 2008). In general, these studies focus on the three issues Easterlin (1974) raised. First,

at one point in a country, are residents with higher incomes happier? Second, are residents of high-income countries happier when compared cross-country? Third, does income growth lead to increased happiness over time? However, only a few literatures have explored the impact of residents' income level on their happiness. Using data on European residents, Clark *et al.* (2011) found in an empirical study that residents living in communities with higher income levels reported higher levels of satisfaction, and these findings held even when personal income was controlled. They believe that the increase of community income level will increase the supply of public goods, thus improving residents' happiness.

The same situation happens in rural China with population hollowing. Under the attraction of relative wages, the surplus labor force in rural areas transfers from agricultural production to industry or service industry, which will bring about a considerable wage income and improve household income. With the increasing number of migrant workers in a village, the overall income level at the village level will also be improved, which will have a positive impact on the happiness of rural residents. However, the increase of village income has a marginal diminishing feature for the improvement of happiness. In other words, with the increasing hollowing of the rural population, although the overall income level of the village continues to increase, its effect on the happiness will become smaller and smaller.

Environmental Improvement Effect. Air pollution, climate deterioration, natural disasters and other ecological and environmental problems will have a significant negative impact on residents' happiness (Ferrer-i-carbonell and Gowdy, 2007; Welsch, 2006, 2009; Luechinger and Raschy, 2009). The outflow of rural labor has greatly reduced agricultural production activities, and the idle of farmland has brought hard-won breathing opportunities to the natural environment, which has played an ecological restoration role to a certain extent. At the same time, the reduction of household garbage will improve the living environment in rural areas and improve the happiness of rural residents. However, the environmental improvement effect brought by the population hollowing has a protracted nature, and the short-term impact is small or hard to observe.

Left-behind Problem. With the working-age population migrates out of village, only children, the elderly and women are left in the countryside, which brings a series of problems. Such as children's education, psychology, future development and other issues (Wen and Lin, 2012; Lu *et al.*, 2016; Lei *et al.*, 2018; Zhao *et al.*, 2018), the elderly' physical and mental health (Chang *et al.*, 2011; Huang *et al.*, 2015; Connelly and Maurer-Fazio, 2016; Ao *et al.*, 2016), women's heavy labor and mental stress (Wu and Ye, 2016). There is no doubt that these left-behind problems will have a negative impact on the happiness of those left-behind group people. Previous study has shown that happiness is contagious (Knight and Gunatilaka, 2009). In a village with low hollowing degree of population, left-behind may not be a serious problem because there is enough male labor stay in rural area. However, when the population hollowing of village is at a high level, left-behind people are widely distributed in villages, and the depression of old people and children being left unattended will become a common phenomenon. The negative emotions of left-behind people will spread throughout the village, and their negative effects on happiness will be contagious. Therefore, population hollowing will have a general negative impact on the happiness of rural residents.

Cultural Absence Effect. The positive impact of cultural activities on happiness has been confirmed by many studies (Ateca-Amestoy *et al.*, 2014; Stenseng *et al.*, 2015). The diversity of

cultural activities can help people in poor get rid of poverty psychology and then out of poverty. However, the outflow of rural young and middle-aged labor force make it difficult to carry out rural cultural activities, and the village culture will also be "hollowing-out", which is manifested by the weak cultural demand, single form of cultural activities and the gradual decline of traditional culture. Obviously, this is not conducive to the spiritual and cultural life of rural residents, leading to the loss of happiness.

Rural Democracy Weakening Effect. Under the background of urbanization, capable young and middle-aged people in villages are the first to leave rural areas for work in cities, or even move out of their families, leaving behind mostly the elderly, the sick and the disabled. The left-behind group is not able to shoulder the heavy responsibility of rural governance, which is not conducive to the smooth implementation of villagers' self-government and democracy. Previous literatures have found that democracy can bring an improvement in happiness (Frey and Stutze, 2000; Dorn *et al.*, 2007;). Chen *et al.* (2014) found that democracy in rural China has a significant positive impact on the happiness of rural residents, so the weakening of village democracy caused by population hollowing is not conducive to the improvement of happiness of rural residents.

2.2 Why there is an inverted U-curve between population hollowing and happiness?

As shown above, the hollowing of village population will have a positive impact on happiness through income growth and improvement of living environment, and will also have a negative impact on happiness through left-behind problems, lack of culture and weakened rural democracy. Whether the population hollowing will bring a loss of happiness or an increase in happiness for rural residents depends on whether the positive or negative effects are greater. This paper holds that, with the development of population hollowing, the power balance between positive effects and negative effects will change, so there is not a single linear relationship between population hollowing and happiness.

In the stage with a low degree of population hollowing, the migrant workers will bring a considerable improvement of the village income level, which will greatly increase the happiness of the rural residents. At this time, due to the small scale of labor outflow, there is still abundant labor force in the village, and the left-behind problem, cultural absence effect and weakening effect of rural democracy are not prominent. As a result, the positive effect dominated by income effect is greater than the negative effect, and population hollowing will bring an increasing in rural residents' happiness.

With the further improvement of population hollowing, the power balance between positive and negative effects will change. First, under the law of diminishing marginal returns, the effect of income growth on happiness is getting smaller and smaller. Secondly, with the massive outflow of labor force, there will be a large number of depression phenomena such as deserted fields, sparsely populated villages, unattended old people and children. Negative effects such as left-behind problems, cultural deficiency effect and weakening effect of rural democracy will become increasingly prominent. Combined with the long-term nature of environmental improvement, the negative effects are far greater than the positive effects. It means that population hollowing leads to the loss of happiness of rural residents.

Therefore, we propose the following research hypothesis: there is an inverted U-shaped curve between the hollowing degree of village population and the happiness of rural residents. That is, in the process of urbanization, a certain degree of population hollowing will have a positive impact

on the happiness of rural residents, and after exceeding the optimal level, population hollowing will lead to a loss in happiness. There is a "Happiness Inflection Point" between the two stages.

3. The empirical analysis

3.1 Data

The database we used comes from field investigation led by the authors. From 2011 to 2017, we surveyed rural China six times and a representative database was collected. In the first two rounds, two or three counties were randomly selected from each selected province, then eight villages were randomly selected from each county, and then 15 households were randomly selected from each village. The first round collected 938 samples from 64 villages in 8 counties of 4 provinces and the second round collected 1320 samples from 88 villages in 11 counties of 5 provinces. In order to cover a wider range of samples, we adjusted the sampling method since the third round. 19 or 22 provinces were randomly chosen from the whole China, then we selected 1-2 counties from each province, then 1-2 villages were randomly selected from each county, and then 15 households were randomly selected from each village. The third round collected 574 samples from 38 villages in 19 counties of 19 provinces, the fourth round collected 922 samples from 66 villages in 33 counties of 22 provinces, the fifth round collected 645 samples from 43 villages in 22 counties of 22 provinces, and the last round collected 570 samples from 38 villages in 19 counties of 19 provinces. Finally, the independently pooled cross-section database contains 4969 samples from 336 villages.

The field investigations include individual-level and village-level questionnaires. In the individual-level, we selected rural residents' self-reported happiness, demographic information and their households' income. In the village-level, the population, self-management, public goods and other information were obtained through the interview with the village heads. All the questionnaires are carried out in the form of face-to-face surveys which are completed by college teachers and graduate students, ensuring the authenticity and reliability of the data. After removing the missing data, our empirical model used 4,451 rural samples from 298 villages in 97 counties and 22 provinces.

3.2 Empirical Methodology

In order to test the non-linear relationship between the degree of population hollowing and happiness, we add a quadratic term of population hollowing index into a traditional happiness empirical model

$$Happy_{ij} = a_1 Hollow_j + a_2 hollow_j^2 + Z_{ij}\lambda + \varepsilon_{ij} \quad (1)$$

where $Happy_{ij}$ is the self-reported happiness of individual i from village j , and $Hollow_j$ is the population hollowing index of village j , Z_{ij} is a set of control variables both come from individual-level and village-level, and ε_{ij} is error term. We also control the province's and year's fixed effects. a_1 and a_2 are the core coefficients which we concern, a_2 is expected to be negative according to our theoretical hypothesis.

The economic literature on happiness mainly uses two models to estimate the impact of

different factors on happiness. The first is to take happiness as the continuous number and run OLS regressions. The second way is to regard happiness as an ordinal variable and adopt Ordered Probit or Logit Model. Ferrer-i-carbonell and Frijters (2004) points out that the results estimated by the two methods have a high degree of consistency in significance and coefficient symbols and little diffidence between the regression coefficient values. Due to the intuitive marginal effect of the results estimated by OLS, this paper mainly use OLS method to estimate the impact of village population hollowing index on the happiness of rural residents.

The model presented by the formula (1) may be plagued by potential endogenous problems. In the happiness determination equation above, individual and village characteristic were added and fixed effects of time and province were controlled, so as to try to overcome errors caused by omitted variables. However, subjective variable is affected by many factors, so that relevant unobserved variables may still be neglected and lead to an endogenous problem. In addition, there may be a reverse causality between happiness and population hollowing.

In this paper, there is an instrumental variable strategy used to test the endogeneity of the above model and correct potential errors. Since the potential endogenous variables appear in the model in the form of quadratic form, we use the Control Function (CF) to estimate the model. CF method has been widely used to solve the endogenous problems of non-linear model. Follows Wooldridge (2015), CF method can be realized through the following two steps. The first step is to make regression between endogenous variables and instrumental variables with exogenous control variables:

$$Happy_{ij} = a_1 IV_1 + a_2 IV_2 + Z_j \lambda + u_{ij} \quad (2)$$

where IV is the instruments we chose for population hollowing index of village j , which is related with population hollowing index and independent of ε_{ij} . OLS can be used to obtain the estimator of residual term $\hat{u}_{ij}$, and put $\hat{u}_{ij}$ into the happiness determining equation of the second stage:

$$Happy_{ij} = \rho_1 Hollow_j + \rho_2 hollow_j^2 + \gamma \hat{u}_{ij} + Z_{ij} \delta + e_{ij} \quad (3)$$

If the residual term estimation coefficient γ is significantly non-zero, then population hollowing index is endogenous, and the estimator of residual term $\hat{u}_{ij}$ should be added as a control variable into the model to correct the bias caused by the endogenous problems. If the assumption of " $\gamma=0$ " is accepted, it means that there is no serious endogenous problem in the model and OLS estimation results are still reliable.

3.3 Variables

Happiness. A measure of happiness was obtained by asking "If you evaluate how happy you were last year, how many points can you score", with options of response including "very unhappy" scored as 1 and going up to 10 indicating "very happy." The average happiness from 2011 to 2016 was 6.8, 7.2, 7.6, 7.8, 7.2 and 8.1, respectively, which shows a generally increasing trend, except for the decline in 2015.

Population Hollowing Index. The degree of population hollowing is the main explaining variable. The essence of the population hollowing is that the working-age population migrates out of the village and into urban areas, so it's advisable for us to construct the Population Hollowing Index(henceforth PHI) from labor mobility perspective to reflect the degree of hollowing. We define the PHI as the ratio of the number of migrant workers to the total population of the village. Migrant workers refers to the workers who have worked outside the county for more than 6 months, and total population is the total registered resident of the village. In the *Robustness Check*, we also replace total population as total labor force. The number of migrant workers and registered population are both from village-level data, which are obtained through interviews with village head. The average PHI of the 298 sample villages was 21.198, with a maximum value of 65.116 and a minimum value of 0.

Control Variables. Our control variables are set as the most previous research. The individual characteristics include age, gender, years of education, marital status, health status and household per capita annual income. The other group is the village characteristic variable, including the distance to the township, the village size, whether the village has a primary school, the number of spontaneous economic cooperative organizations and the number of villagers' congresses held in the year under investigation. The village size is measured by the number of household, whether the village has a primary school reflects the supply of public goods, spontaneous economic cooperative organizations reflects the degree of cooperation in economic life and villagers' congresses reflect the democracy of the village. Detailed definitions are shown in table 1.

In terms of individual characteristics, 84% samples were male, and the average age of was 51.239 years old, with an average years of education of 6.505 years. Among the respondents, 92.4 percent of rural residents are married, while less than 18 percent consider themselves unhealthy. In terms of families, the average annual income per capita of the 4,451 households reached 12211.38 yuan, of which the maximum value was 501,220 yuan and the minimum value was 0 yuan. The 298 villages surveyed are 7.849 kilometers away from towns and villages on average. The average size of villages is 471.742 households. The average number of villagers' congresses in the survey year is 3.097 and the average number of spontaneous economic cooperative organization is less than one. Detailed descriptive statistical analysis of all variables is shown in table 2.

3.4 Results

In this paper, Variance Inflation Factor(VIF) is used to test the problem of multicollinearity. Except the square term, VIF values of all explanatory variables are less than 5, and there is no serious multicollinearity problem in the model.

OLS Results. First, Column (1) of Table3 regresses the happiness of rural residents on the PHI of the village and its square term. Secondly, Column (2) adds individual characteristic of rural residents into the model and control the fixed effect of year and province. Finally, Column (3) adds the village characteristic.

Table3 reports the OLS results. Without any control variables, the PHI and its square term are significant at 1% statistical level, and the square term coefficient is negative. It can be found that after adding individual, village characteristic variables and controlling the fixed effect of year and province, the PHI and its square term are still significant at the statistical level of 1%, and the direction of coefficient remains the same. The results indicate that there is an inverted U shaped curve between the PHI of village and the happiness of rural residents. With the increase of PHI,

the happiness of rural residents shows a trend of increasing first and then decreasing.

The estimations of control variables are basically consistent with previous studies. There is a U-shaped curve relationship between age and happiness which is basically consistent with most research (Winkelmann and Winkelmann, 1998; Frey and Stutzer, 2000; Alesina *et al.*, 2004). The happiness of female rural residents was higher than that of male residents, and the higher the education level of rural residents was, the higher the happiness level was, which was consistent with the research results of Blanchflower and Oswald (2004) and Fahey and Smyth (2004). The happiness of the rural residents who report their health status as "average" and "unhealthy" are lower than that of the healthy rural residents. Most studies show that married people are happier, people with poor health are less happy too (Dolan *et al.*, 2008; Frey and Stutzer, 2002). Democracy represented by villagers' congresses has positive effect on happiness, consistent with Frey and Stutze(2000), Dorn *et al.*(2007) and Chen *et al.*(2014).

IV Estimates. We choose two exogenous instruments for the PHI. First is the population hollowing index of the county where the village located in(henceforth, PHIC). Within the county, all villages are affected by common socio-economic factors, and the degree of population hollowing may be highly correlated. At the same time, the counties' population hollowing index can be regarded as exogenous variable relative to a specific village. Therefore, the hollowing degree of rural population in county areas meets the requirements of relevance and exogeneity, and is an available instrument. With reference to Chen *et al.* (2018) and based on the 2010 Population Census data, we use the difference between population outflow rate and inflow rate to reflect the hollowing degree of rural population in each county. The PHIC in 2010 is highly relevant to PHI in the village, although there may be some difference between the actual PHIC in the survey year. Another instrument is the proportion of wage income in the per capita net income of rural residents in the province where the village is located(henceforth, PWIP). PWIP is accounted to response the income sources of rural residents. Undoubtedly, migrant workers in urban are an important source of rural household's wage income, the greater instructions of the income sources, the higher the proportion of migrant workers in the province, and the greater the proportion of rural labor outflow, the higher degree of population hollowing may be. Seem like PHIC, the index from province-level can be regarded as exogenous variable relative to a specific village. All the income data selected from China Statistical Yearbook2011-2017. The IV estimates results are shown in columns 4 and 5 of table 3. In the first stage, the coefficient of instruments have a positive impact on the PHI at the statistical level of 1% and 10% respectively, which is consistent with the theoretical expectation and also shows the availability of instruments. While, in the second stage, the residual term estimation coefficient could not pass the significance test, indicating that the model did not have serious endogenous problems and could accept OLS estimation results.

According to Column (3), the estimate of the PHI to be 0.025 (s.e. =0.008) which is statistically significant at 1% level of significant, and the estimate of its square term to be -0.0004 (s.e. =0.0001) which is statistically significant at 1% level of significant. That means there is an inverted U shaped curve between the PHI of village and the happiness of rural residents. The PHI corresponding to the "Happiness Inflection Point" is $31.25[-0.0004 / (2*0.025)]$. In our sample villages, nearly 80% villages' PHI is less than 31.25. This shows that the population hollowing degree of most villages is still at the left side of the inverted U curve, and there is still some distance from the "Happiness Inflection Point". At present and in the short term, the increase of

population hollowing will not cause the loss of happiness of the rural residents. Our theoretical hypothesis is well proved

3.5 Robustness Check

According to the above analysis, there is a significant inverted U-shaped curve relationship between the hollowing of rural population and the happiness of rural residents. In order to ensure the robustness of the regression result, we adopted the following methods for robustness test.

Generalized Propensity Score Matching. In order to better test the inverted U-shaped curve relationship between the PHI and happiness, the Generalized Propensity Score Matching(GPS) is used to investigate the treatment effect of different population hollowing levels on happiness in this section. GPS is a non-parametric method proposed by Hirano and Imbens (2004) which could control the difference between covariates and correct for selection bias in settings with continuous treatment (Kluve *et al.*,2012).

The GPS can be realized through the following steps. We first regress the PHI on control variables to calculate the generalized propensity score. Kolmogorov-Smirnov equality-of-distributions test provides strong support for the hypothesis of a normal distribution of our treatment variable PHI¹. We have five approximately similar-sized groups based on their actual PHI. According to a standard two-sided t test, the balancing property is satisfied at a level lower than 1%. The next step is to estimate the Dose Response Function(DRF) to reflect the causal link between happiness and each dimension of the PHI. Happiness is taken as the explained variable, and the high order term of PHI and the high order term of generalized propensity score are taken as the explained variables². OLS was used to obtain the estimators of parameters. The results are summarized in tables4. The coefficients of the PHI and generalized propensity score are highly significant, that means there may be the existence of self-selection into different population hollowing intensities. Finally, according to the parameter estimation of the DRF, the causal effects of different PHI intensities on happiness are calculated.

Figure3 provides graphical representations of the DRF and Treatment Effect Function. From the DRF, it can be seen that there is an obvious inverted U-shaped curve relationship between PHI and happiness. From the trend of the Treatment Effect Function, with the increase of PHI, the positive treatment effect of population hollowing on happiness gradually weakens. After the inflection point, the treatment effect turn to be negative, the “happiness effect” will turn into a inhibitory effect, and the inhibitory effect will become stronger and stronger. This is consistent with our theoretical expectations.

Another Measure of PHI. In above, we define the PHI as the ratio of the number of migrant workers to the total population of the village. Here, we replace “total population” as “total labor force”. In our database, 281 villages reported a total workforce. The mean value of the new PHI is 42.0, a maximum of 100, and a minimum of 0. Column (1) of table 4 reports the regression results. Both the new PHI and its square term have a significant impact on happiness, and the coefficient of the square term is negative. This again shows that there is a significant inverted U-shaped curve relationship between the hollowing of rural population and the happiness of rural residents.

Other Estimation Methods. Ordered and binary probit model are also adopted in this paper to test the robustness of our results. First, happiness is regarded as an ordered variable, and the

¹ A zero-skewness log transformation was applied to normalize the PHI. The assumption of Normality is statistically satisfied at 5% level.

² The generalized propensity score coefficients control for selection bias in the different treatment intensities.

Ordered Probit Model (OP) is used to estimate. Secondly, we transform happiness to a binary variable, and Binary Probit Model (BP) was used to test the relationship between the PHI of village population and the happiness of rural residents. Since the average happiness of the 4,451 rural residents is 7.408, the samples with happiness greater than 7 are deemed as happiness and are assigned a value of 1. The sample with happiness less than or equal to 7 is regarded as unhappy and assigned a value of 0.

The regression results are shown in table 4, column (2) and column (3). It can be seen from the comparison between column (3) of table 3 and column (2) of table 4 that the results of OLS and OP are basically the same except for slight differences in coefficient and standard error, which further verifies the research conclusion of Ferrer-i-carbonell and Frijters (2004). In the OP model, the PHI and its square term are both significant at the 1% statistical level, and the square term coefficient is negative. The estimation results in column (3) of table 4 also show that the PHI and its square term are still significant at the statistical level of 1%, and the square term coefficient is negative. In other words, the conclusion that there is an inverted U-shaped curve between the hollowing of the rural population and the happiness of rural residents is robust.

4. Mechanism Research

Above, we prove that population hollowing has an inverted U-shaped relationship with happiness. In this section, we discuss specifically whether there are positive and negative mechanisms as hypothesized by the theory which infer the income effect, environmental improvement effect, the “left-behind” problem, a lack of culture, and the weakening of rural democracy.

4.1 Empirical Strategy

For the positive mechanism, according to the theoretical hypothesis, the increase of village income level brought by population hollowing has a diminishing positive impact on happiness under the law of diminishing marginal utility. In other words, for villages with a low degree of PHI, there is an intermediary mechanism of "population hollowing-income level-happiness", but this intermediary effect does not exist or is not significant when the degree of population hollowing exceeds the "Happiness Inflection Point". Therefore, we check the mediating effect of income level for the both village with high PHI and low PHI. Our estimation results above show that 31.25 is the optimal size for the PHI, so based on whether the PHI is less than 31.15, the sample is divided into two parts: the left side of the "Happiness Inflection Point" and the right side¹. The expected conclusion is that for the villages on the left side of the curve, there is a significant mediating effect of "population hollowing-income-happiness", while the mediating effect on the right side does not exist or is not significant.

Since the effect of environmental improvement is difficult to be observed in a short period of time, and the time span of our database is insufficient to capture the mediating effect of environmental improvement, this section does not test the mechanism of environmental improvement.

As to the negative mechanism, we use the following strategy. First, we will test the mediating effect model in the whole sample. If we can't reject the hypothesis that there is a significant

¹ Here, in the left side of the curve, the population hollowing leads to increased happiness, and in the right side, the population hollowing brings a loss in happiness.

mediating effect, it indicates the negative mechanism exists at all levels of PHI. Otherwise, we will check the right side of the curve, if estimated results support the hypothesis of the existence of mediating effects, means that the negative effect only works when the PHI reach a certain high level. That also means that the negative effect of population hollowing on happiness increases with the rising of the PHI which coincides with our theoretical hypothesis.

A simply Structural Equation Model is used to test and verify our mechanisms,

$$\begin{cases} Happiness_{ij} = a_1Hollow_j + Z_{ij}\lambda_1 + \varepsilon_{1ij} \\ Mediator_j = a_2Hollow_j + Z_{ij}\lambda_2 + \varepsilon_{2ij} \\ Happiness_{ij} = a_3Hollow_j + c \cdot Mediator_j + Z_{ij}\lambda_3 + \varepsilon_{3ij} \end{cases} \quad (4)$$

where $Mediator_j$ is the mediating variable, coefficient a_1 measures the total effect of the PHI on happiness, a_2 represents the influence of the PHI on the mediating variable, a_3 is the direct effect of the PHI on happiness.

4.2 Results

Table 6 reports the result of the income effect. We use the "per capita net income in the village" reported by village head as the proxy variable for the village income level. But, there were almost 20% missing values in the sample, 57 missing values in 298 sample villages. Therefore, we handle missing values with linear interpolation method, and take logarithms in the model. For villages located on the left side of the curve, the PHI has a significant positive impact on village income level, which in turn has a significant positive impact on residents' happiness. Therefore, there is a mediating effect of "population hollowing-income-happiness". Sobel test also show a significant mediating effect. For villages located on the right side, the PHI does not affect the village income level, and the impact of village income level on residents' happiness is also not significant, so the mediating effect is not significant, which is also confirmed by Sobel test. Therefore, the theoretical hypothesis has been verified, that is, the increase of income level brought by population hollowing has a positive impact on residents' happiness, but after the population hollowing reaches the optimal level, under the law of diminishing marginal utility, the effect of income on happiness becomes insignificant.

Different mediating variable are chosen as the proxy variables of the negative mechanisms proposed by the theoretical framework. We use the proportion of the resident population over 65 years old to reflect the left-behind degree of a village. It's worth noting that this index only reflects the situation of left-behind elderly people, and may underestimate the impact of left-behind problems on residents' happiness, but this does not prevent us from testing whether there is a mediating effect. Table 7 shows that for all the samples, although PHI has a significant positive impact on the left-behind problem, the left-behind problem does not affect residents' happiness, so there is no mediating effect. One possible explanation is that rural residents are not sensitive to the left-behind problem when the degree of population hollowing is relative low, and the non-serious left-behind problem will not affect the residents' happiness. Therefore, it also means that for villages with a high degree of population hollowing, serious left-behind problems will have a significant negative impact on residents' happiness. For the sample on the right side of the curve, we can see in Column (4)-(6) of table 7, the PHI has significant positive impact on the left-behind

problems, and the left-behind problems also has a significant negative impact on happiness, therefore there is a the mediation effect of "population hollowing - left-behind problem - happiness" and Sobel test confirmed the conclusion.

Finally, we examine the mediating effects of cultural and rural democracy absence. Cultural and entertainment organizations spontaneously established by rural residents are the main organizer of the rural cultural activities, so we use the number of spontaneous cultural and entertainment organizations to reflect the development of cultural and entertainment activities in a village. There is a village which has set up 12 organizations, including the elderly association, *Yangko* team, chess and card association, etc., however, nearly 67% of the villages have not set up any organizations in 298 sample villages. In the model, we add 1 and take the logarithm to all villages. It can be seen from Column (1)-(3) of table8 that the PHI has a negative impact on the development of cultural and entertainment organizations, while the development of cultural and entertainment organizations has a positive impact on the happiness of rural residents. Therefore, the "cultural hollowing" caused by population hollowing can inhibit the improvement of rural residents' happiness, and the medicating effect is confirmed. The village party branch is the leading core of villager self-management. The quality of its members directly determines the effect of self-management and the development of village democracy. Therefore, we use the proportion of party members with high school education or above in the village party branch to reflect the situation of self-management and democracy. It can be seen from the estimation results in Column (4)-(6) of table8 that the higher PHI, the lower the proportion of party members with high school education or above will be, and the villagers' democracy reflected by this index has a positive impact on the happiness. It refers the brain drain and lack of democracy caused by population hollowing is not conducive to the improvement of rural residents' happiness, and the medicating effect is confirmed.

So far, we find that the hollowing of rural population improves residents' happiness by increasing the village income level, and negatively affects residents' happiness by affecting left-behind issues. In addition, the population hollowing is not conducive to cultural activities and villagers' self-governance, and thus restraining the improvement of happiness. However, the income effect will not be significant when the population hollowing degree reaches a certain level, and the mediating effect of left-behind problem is significant for villages with high degree of population hollowing. In other words, with the increase of population hollowing, the positive effect will become smaller, while the negative effect will become larger. Therefore, the influence of the hollowing of rural population on the happiness presents an inverted U-shaped curve. Theoretical framework proposed by this paper is confirmed again.

5. Heterogeneity Research

In this section, the heterogeneity of the sample will be fully considered. In particularly, we discuss in detail how the hollowing of rural population affects residents with different levels of happiness, the elderly and rural female residents.

5.1 Residents with Different Happiness Levels.

As we known from the above analysis, with the increasing hollowing of rural population, the population hollowing of the village will eventually lead to a loss in happiness of rural residents. So is there a difference in the impact on rural residents with different levels of happiness?

We believe that the rural residents with higher happiness are more sensitive to the degree of population hollowing. Residents with a high sense of happiness tend to have individual characteristics such as high income, good physical health, and family harmony. Whether their life satisfaction can improve depends more on the external favorable environment. When the hollowing degree of the village population exceeds the "Happiness Inflection Point" and continues to increase, the deterioration of the external environment will have an immediate negative impact on their happiness. As to the rural residents with low happiness, they pay more attention to how to improve their individual characteristics but not the external environment, so they are not sensitive to population hollowing.

Quantile Regression is used to explore the differences of rural residents with different levels of happiness in their responses to population hollowing in this section. As can be seen from the regression results in table9, the PHI and its square term are not significant for the 0.2 quantile, while above the 0.3 quantile, the population hollowing and happiness show a significant inverted U-shaped curve relationship, which indicates that population hollowing does not affect residents in low happiness. The subsample regression in table10 also shows that the inverted U-shaped curve relationship between population hollowing and happiness is satisfied for groups with high happiness who has high income, physical health and get married. While the inverted U-shaped curve relationship is not significant for people with low happiness who has low income, is unhealthy and unmarried¹. In addition, the PHI corresponding to the "Happiness Inflection Point" between 0.3 and 0.8 quantile is 30, 33.75, 18, 18, 15 and 16, respectively. It can be seen that the "Happiness Inflection Point" of rural residents with higher happiness appears earlier, indicating that residents with higher happiness are more sensitive to population hollowing. In other words, when the population hollowing exceeds the "Happiness Inflection Point", the happiness of the originally happiest rural residents will first decline, and then the overall happiness of rural residents will be reduced.

5.2 The Elderly.

The hollowing of rural population may have different effects on different age groups, and the elderly has always been the focus of scholars. Previous literatures have discussed the impact of adult child migration work on the health of left-behind elderly people. Some studies believe that the elderly cannot get the life care and spiritual comfort of their children, which will have a negative effect on their health (Antman, 2010), leading to the decline of happiness. However, there is also concluded that the development of modern communication tools can alleviate the loneliness of the elderly (Baldassar, 2007), and at the same time, the children's out-migrating for work increases their ability to support their parents, which is beneficial to the health of the elderly (Knodel *et al.*, 2010; Kuhn *et al.*, 2011), promoting happiness.

It can be seen that population hollowing has both negative and positive effects on the elderly, we should not only see the negative impact, but also the positive side. First, children's financial support can improve the elderly's economic conditions and quality of life. Secondly, both parents want their children to have a good future development, their children can get a better income from working in cities, and even moving out of the countryside to settle down in cities and live a better life, which can meet the expectations of the elderly and thus improve their happiness. Therefore,

¹ The sample is divided into the high-income group and the low-income group by taking the average annual income per capita of the sample as the boundary.

the relationship between village population hollowing and the happiness of the elderly should also show an inverted U-shaped curve. That is, in the initial stage, with the increase of population hollowing, the improvement of economic conditions and the expectation of children's future economic and social status, the happiness of the elderly shows an upward trend. However, with the further increase of population hollowing, the negative effect gradually appears and exceeds the positive effect, and the happiness of the elderly will show a declining trend.

For the sake of robustness, 50, 55, 60 and 65 years old are selected as the critical values of the elderly in this paper. The estimated results are shown in table 11. In addition to the 60 years old as the dividing standard, the PHI and its square term in the other three dividing subsample have a significant impact on happiness statistically, and the square term coefficient is negative. This shows that there is a significant inverted U-shaped curve relationship between the population hollowing of the village and the happiness of the elderly. According to the parameter estimation reported in column (4) of table 10, the PHI of the village corresponding to the "Happiness Inflection Point" of the elderly is 32.5. Among the 230 sample villages, 186 (80.87%) had a hollowing index less than 32.5, and only 44 (19.13%) had a hollowing index greater than 32.5. In general, the degree of population hollowing in most villages has no negative impact on the happiness of the elderly.

6. Conclusion

In the process of China's rapid urbanization, the hollowing of rural population is an irreversible objective fact. Under the background of hollowing out of the rural population, most observers only have the image that the farmers' life is worrying and the countryside is in a state of desolation. However, based on the survey of 4969 households from 336 villages in 22 provinces and the Chinese General Social Survey (CGSS) we find that the rural residents' happiness does not decline significantly in the rural population hollowing in China.

There will be an inverted U-shaped curve between the hollowing degree of village population and the happiness of rural residents according to our theoretical framework. We believe that the population hollowing will affect happiness through five channels, including an income effect, environmental improvement effect, the "left-behind" problem, a lack of culture, and the weakening of rural democracy. Migrant workers can increase their income significantly compared to their earnings had they stayed in the village, and so a higher population hollowing in the villages correlates with a higher income level which has a positive effect on happiness. Environmental improvement effect means that the reduction of the population will alleviate ecological environmental pressures from overpopulation and lack of quality infrastructure, which leads to an improvement in the living environment of remaining residents; this also has a positive impact on happiness. With the increase of population loss, the left-behind problem gradually becomes more prominent which leads to social instability and thus have a negative impact on happiness. Beyond that, the outflow of labor makes rural cultural activities and democracy difficult to be carried out effectively, hindering the improvement of happiness. The total effect of population hollowing on happiness depends on the magnitude of these positive and negative effects. In the stage with a low degree of population hollowing, the positive effect dominated by income effect is greater than the negative effect, and population hollowing will bring an increasing in rural residents' happiness. With the further improvement of population hollowing, the negative effects are far greater than the positive effects. It means that population hollowing leads to the loss

of happiness of rural residents. Therefore, an inverted U-shaped curve will be there.

Empirical research confirms our theory and explanation. Based on the data of 4451 households in 298 villages from the database mentioned above, using a model with a quadratic term, we find there is a significant and robust inverted U-shaped relationship between the degree of population hollowing and the happiness of rural residents. Almost 80 percent of the investigated villages' population hollowing are less than the degree of hollowing corresponding to the turning point, so that the increase in the degree of rural population hollowing will not cause a loss of happiness within a short period of time. We also verified the mechanism in the theoretical model by using mediation models and discuss the heterogeneity of population hollowing's impact on different populations.

This finding makes marginal contribution to the development of happiness economics and development economics. In the historical process of urbanization in developed countries such as Europe and America, there is no survey on the happiness or life satisfaction of rural residents, so it is impossible to study how the hollowing of rural population will affect the happiness of rural residents. The emergence of happiness economics and the ongoing urbanization process in China make it possible for this paper to study the impact of the population hollowing on the happiness of rural residents. The inverted U-shaped curve residents reveals that the hollowing of rural population does not always lead to the reduction of the welfare of rural residents. In a certain period of time, the hollowing out of rural population is helpful to increase the happiness of rural residents. This finding may not only exist in the urbanization process of China, but also generally exist in the urbanization process of other developing countries. Scholars are expected to use data from other developing countries to empirically test this finding.

Our findings have important policy implications. To a certain extent, the population hollowing of villages will bring a positive impact on the happiness of rural residents, and the decline of happiness will only be caused when the "Happiness Inflection Point" is reached. This reminds people to need rational understanding rural population hollowing problem. At the current stage, we should not only see all the negative effects brought by the hollowing, but also the positive effects. Only by comprehensively weighing the positive and negative effects can we fully understand the real impact of the population hollowing of rural area. At present, China still has nearly 600 million rural residents living in rural areas. China's urbanization process is far from complete. Fortunately, most of the villages surveyed have not reached the "Happiness Inflection Point". In other words, in the short term, the degree of hollowing population of villages accompanied by further urbanization will not reduce the happiness of rural residents. Harmonious and stable rural society will provide a good external environment for the promotion of urbanization. What's important is that the government needs to think in advance of the loss of rural residents' happiness at the "Happiness Inflection Point" and take corresponding measures to prevent the possible instability of rural society caused by the sharp decline of rural residents' happiness.

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Table1. List of Variables and Definitions

Variable	Type	Description
Outcome		
Happiness	Categorical	Self-reported measure of happiness. The index ranges from 1 (minimum) to 10 (maximum).
Explaining Variable		
HPI	Continuous	Population Hollowing Index. The ratio of the number of migrant workers to the total population of the village.
Individual Characteristics		
Age	Continuous	Age in years
Gender	Indicator	Binary indicator for gender, 1 for male and 0 for female
Edu	Categorical	Education in years
Marriage	Indicator	Binary indicator for marital status, 1 for married and 0 for others
Health ₁	Indicator	Binary indicator for self-reported health, 1 for “not bad” and 0 for others
Health ₂	Indicator	Binary indicator for self-reported health, 1 for “unhealthy” and 0 for others
Ln(<i>I</i>)	Categorical	(Log)Household per capita annual income
Village Characteristic		
Distance	Continuous	The distance between village and township(Kilometers), whether the village has a primary school
Scale	Categorical	The number of household in the village
School	Indicator	Binary indicator for whether the village has a primary school, 1 for “Yes” and 0 for “No”
Organ	Categorical	The number of spontaneous economic cooperative organizations
Democracy	Categorical	The number of villagers' congresses held in the year under investigation

Table2. Descriptive Statistics for Variables

Variable	No.	Mean	St. Dev.	Min	Max
Happiness	4451	7.408	2.068	1	10
HPI	298	21.198	13.698	0	65.116
Age	4451	51.239	12.092	16	93
Gender	4451	0.840	0.367	0	1
Edu	4451	6.505	3.402	0	18
Marriage	4451	0.924	0.265	0	1
Health ₁	4451	0.339	0.474	0	1
Health ₂	4451	0.179	0.383	0	1
Ln(<i>I</i>)	4451	8.846	1.154	0	13.125
Distance	298	7.849	7.652	0	68
Scale	298	471.742	303.618	61	2685
School	298	0.611	0.488	0	1
Organ	298	0.862	1.103	0	6
Democracy	298	3.097	4.137	0	32

Table3. The Effect of PHI on Happiness: OLS and IV Estimation

	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	IV-1	IV-2
PHI	0.039^{***} (0.007)	0.0264^{***} (0.008)	0.025^{***} (0.008)		0.044 [*] (0.026)
PHI ²	-0.0005^{***} (0.0001)	-0.0004^{**} (0.0001)	-0.0004^{***} (0.0001)		-0.0004 ^{**} (0.0001)
PHIC				0.184^{***} (0.026)	
PWIP				0.146[*] (0.076)	
Residuals					-0.020 (0.025)
Age		-0.041 ^{**} (0.016)	-0.041 ^{**} (0.016)		-0.041 ^{**} (0.016)
Age ² /100		0.001 ^{***} (0.0002)	0.001 ^{***} (0.0002)		0.001 ^{***} (0.0002)
Gender		-0.131 (0.083)	-0.129 (0.083)		-0.129 (0.083)
Edu		0.047 ^{***} (0.010)	0.049 ^{***} (0.010)		0.049 ^{***} (0.010)
Health ₁		-0.483 ^{***} (0.067)	-0.470 ^{***} (0.067)		-0.471 ^{***} (0.067)
Health ₂		-1.260 ^{***} (0.095)	-1.250 ^{***} (0.095)		-1.250 ^{***} (0.095)
Marriage		0.338 ^{**} (0.124)	0.336 ^{**} (0.124)		0.335 ^{**} (0.124)
Ln(I)		0.284 ^{***} (0.031)	0.286 ^{***} (0.031)		0.287 ^{***} (0.031)
Distance			0.016 ^{***} (0.004)	-0.007 (0.021)	0.016 ^{***} (0.0034)
Scale			-0.0001 (0.0001)	0.002 ^{***} (0.001)	-0.0001 (0.0001)
School			-0.154 [*] (0.072)	-6.703 ^{***} (0.437)	-0.031 (0.169)
Organ			0.094 ^{**} (0.029)	0.056 (0.244)	0.092 ^{**} (0.029)
Democracy			0.036 ^{***} (0.00867)	-0.018 (0.056)	0.037 ^{***} (0.009)
Constant	6.900 ^{***} (0.093)	4.538 ^{***} (0.472)	4.287 ^{***} (0.474)	4.070 (3.967)	4.033 ^{***} (0.557)
Fixed Effect	No	Yes	Yes	Yes	Yes
R ²	0.008	0.183	0.192	0.251	0.192

Note: Heteroskedasticity robust standard error in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table4. Does Response Function Estimation for Happiness

	Coef.	Std. Err.
HPI	0.040***	0.009
HPI ²	-0.001***	0.0002
Pscore	-2.531**	1.260
Pscore ²	4.301**	2.061
Pscore ³	-2.038**	0.986
Constant	7.233***	0.218

Note: *** p<0.01, ** p<0.05, * p<0.1.

Table5. Robustness Check for the Inverted U-shaped Curve Relationship

	(1) New Measure	(2) Ordered Probit	(3) Binary Probit
PHI	0.016*** (0.005)	0.015*** (0.004)	0.020*** (0.005)
PHI ²	-0.0001*** (0.0001)	-0.0002*** (0.0001)	-0.0004*** (0.0001)
Age	-0.049** (0.017)	-0.023** (0.009)	-0.027** (0.012)
Age ² /100	0.0007*** (0.0002)	0.0004*** (0.0001)	0.0004*** (0.0001)
Gender	-0.099 (0.087)	-0.083* (0.046)	-0.092 (0.057)
Edu	0.050*** (0.010)	0.026*** (0.005)	0.033*** (0.007)
Health ₁	-0.457*** (0.069)	-0.267*** (0.038)	-0.345*** (0.048)
Health ₂	-1.243*** (0.097)	-0.657*** (0.051)	-0.650*** (0.062)
Marriage	0.350*** (0.132)	0.194*** (0.066)	0.170** (0.082)
Ln(I)	0.279*** (0.032)	0.154*** (0.017)	0.188*** (0.023)
Distance	0.019*** (0.004)	0.010*** (0.002)	0.010*** (0.003)
Scale	-0.0001 (0.0001)	-0.0001 (0.0001)	-0.00001 (0.0001)
School	-0.155** (0.076)	-0.079* (0.041)	-0.142*** (0.052)
Organ	0.126*** (0.033)	0.048*** (0.017)	0.071*** (0.023)
Democracy	0.037*** (0.010)	0.0213*** (0.005)	0.017*** (0.005)
Constant	4.443*** (0.490)		-1.968*** (0.341)
Fixed Effect	Yes	Yes	Yes
No.	4196	4451	4451
R ² /Pseudo R ²	0.191	0.052	0.118

Note: Heteroskedasticity robust standard error in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table6. The Medication Model of Income Effect

	Income Effect(Left Side)			Income Effect (Right Side)		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var.	Happiness	Mediator	Happiness	Happiness	Mediator	Happiness
Hollow	0.013*** (0.004)	0.002** (0.001)	0.012*** (0.004)	-0.024** (0.010)	0.002 (0.002)	-0.024** (0.010)
Mediator			0.497*** (0.097)			0.264 (0.184)
Age	-0.056*** (0.018)	-0.0003 (0.003)	-0.056*** (0.018)	0.017 (0.034)	0.007 (0.006)	0.015 (0.034)
Age ²	0.001*** (0.0002)	1.49E-05 (3.04E-05)	0.001*** (0.0002)	8.12E-05 (0.0003)	-4.6E-05 (5.74E-05)	0.0001 (0.0003)
Gender	-0.125 (0.092)	-0.003 (0.016)	-0.123 (0.092)	-0.164 (0.163)	0.001 (0.030)	-0.165 (0.163)
Edu	0.046*** (0.011)	-0.003 (0.002)	0.048*** (0.010)	0.053*** (0.019)	0.011*** (0.004)	0.050** (0.019)
Marriage	0.535*** (0.126)	-0.018 (0.022)	0.543*** (0.126)	-0.237 (0.225)	-0.067 (0.041)	-0.219 (0.225)
Health ₁	-0.501*** (0.076)	-0.036*** (0.013)	-0.483*** (0.076)	-0.365** (0.145)	0.008 (0.027)	-0.367*** (0.145)
Health ₂	-1.260*** (0.099)	-0.079*** (0.017)	-1.221*** (0.098)	-1.142*** (0.186)	0.001 (0.034)	-1.142*** (0.186)
Ln(I)	0.297*** (0.032)	0.038*** (0.006)	0.278*** (0.032)	0.230*** (0.051)	0.023** (0.009)	0.224*** (0.051)
Distance	0.022 (0.005)	-0.002*** (0.001)	0.023*** (0.004)	-0.045*** (0.013)	0.005** (0.002)	-0.046*** (0.013)
Scale	-5.7E-05 (0.0001)	0.0001*** (2.21E-05)	-0.0001 (0.0001)	0.0002 (0.0003)	0.0002*** (5.64E-05)	0.0002 (0.0003)
School	-0.207** (0.085)	-0.027* (0.015)	-0.194 (0.084)	0.242 (0.201)	-0.247*** (0.037)	0.307 (0.206)
Organ	0.094** (0.038)	0.053*** (0.007)	0.067* (0.039)	0.028 (0.074)	0.058*** (0.014)	0.013 (0.075)
Democracy	0.039*** (0.009)	-0.005*** (0.002)	0.041*** (0.009)	0.020 (0.020)	-0.002 (0.004)	0.021 (0.020)
Constant	4.315 (0.588)	8.261*** (0.102)	1.623* (0.937)	5.190*** (1.254)	7.237*** (0.230)	3.279* (1.830)
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.198	0.557	0.204	0.264	0.702	0.265
No.		3543			908	
Sobel Test		0.0008**			0.0006	

Note: Estimation via the Structural Equation Model; standard error in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table7. The Medication Model of Left-Behind Problem

	Left-Behind			Left-Behind (Right Side)		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var.	Happiness	Mediator	Happiness	Happiness	Mediator	Happiness
Hollow	0.003 (0.002)	0.058*** (0.014)	0.003 (0.002)	-0.024** (0.010)	0.326*** (0.065)	-0.020* (0.010)
Mediator			0.003 (0.003)			-0.011** (0.005)
Age	-0.041** (0.016)	-0.254*** (0.093)	-0.040** (0.016)	0.017 (0.034)	-0.490** (0.213)	0.012 (0.034)
Age ²	0.001*** (0.0002)	0.004*** (0.0009)	0.0006*** (0.0002)	8.12E-05 (0.0003)	0.006*** (0.002)	0.0001 (0.0003)
Gender	-0.136** (0.081)	-0.170 (0.473)	-0.135* (0.081)	-0.164 (0.163)	1.328 (1.030)	-0.150 (0.163)
Edu	0.050*** (0.009)	0.024 (0.054)	0.050*** (0.009)	0.053*** (0.019)	-0.066 (0.122)	0.052*** (0.019)
Marriage	0.337*** (0.110)	0.878 (0.647)	0.335*** (0.110)	-0.237 (0.225)	-0.555 (1.421)	-0.242 (0.225)
Health ₁	-0.469** (0.068)	-0.916** (0.398)	-0.467** (0.068)	-0.365** (0.145)	-0.606 (0.914)	-0.371** (0.145)
Health ₂	-1.252*** (0.088)	-0.379 (0.513)	-1.251*** (0.088)	-1.142*** (0.186)	0.819 (1.176)	-1.133*** (0.186)
Ln(<i>I</i>)	0.284*** (0.027)	-0.407 (0.159)	0.285*** (0.027)	0.230*** (0.051)	0.058 (0.321)	0.230*** (0.051)
Distance	0.016*** (0.004)	-0.033 (0.024)	0.016*** (0.004)	-0.045*** (0.013)	0.276*** (0.083)	-0.042*** (0.013)
Scale	-5.3E-05 (0.0001)	-0.004*** (0.001)	-4.3E-05 (0.0001)	0.0002 (0.0003)	-0.002 (0.002)	0.0002 (0.0003)
School	-0.166** (0.074)	-0.114 (0.434)	-0.166** (0.074)	0.242 (0.201)	-2.412* (1.271)	0.217 (0.201)
Organ	0.089*** (0.032)	-0.113 (0.186)	0.089*** (0.032)	0.028 (0.074)	-2.285*** (0.470)	0.004 (0.075)
Democracy	0.036*** (0.007)	-0.227*** (0.043)	0.037*** (0.007)	0.020 (0.020)	0.039 (0.126)	0.021 (0.020)
Constant	4.765*** (0.554)	55.062*** (3.246)	4.622*** (0.572)	5.190*** (1.254)	10.057 (7.915)	5.296*** (1.253)
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
<i>R</i> ²	0.190	0.321	0.190	0.264	0.498	0.267
<i>No.</i>		4451			908	
Sobel Test		0.0001			-0.0003*	

Note: Estimation via the Structural Equation Model; standard error in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table8. The Medication Model of Cultural and Rural Democracy Absence

	Culture			Democracy		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var.	Happiness	Mediator	Happiness	Happiness	Mediator	Happiness
Hollow	0.003 (0.002)	-0.002*** (0.001)	0.003 (0.002)	0.003 (0.002)	-0.001*** (0.0002)	0.003 (0.002)
Mediator			0.153** (0.063)			0.373* (0.200)
Age	-0.041** (0.016)	0.006 (0.004)	-0.042*** (0.016)	-0.038** (0.016)	-0.002 (0.001)	-0.038** (0.016)
Age ²	0.001*** (0.0002)	-3.8E-05 (3.66E-05)	0.001*** (0.0002)	0.001*** (0.0002)	1.69E-05 (1.16E-05)	0.001*** (0.0002)
Gender	-0.136** (0.081)	0.047** (0.019)	-0.143* (0.081)	-0.133 (0.081)	0.012* (0.006)	-0.137* (0.081)
Edu	0.050*** (0.009)	0.004* (0.002)	0.049*** (0.009)	0.050*** (0.009)	0.001 (0.001)	0.049*** (0.009)
Marriage	0.337*** (0.110)	0.016 (0.026)	0.335*** (0.110)	0.327*** (0.111)	0.001 (0.008)	0.326*** (0.111)
Health ₁	-0.469*** (0.068)	0.018 (0.016)	-0.472*** (0.068)	-0.472*** (0.068)	-0.001 (0.005)	-0.472*** (0.068)
Health ₂	-1.252*** (0.088)	0.016 (0.021)	-1.255*** (0.088)	-1.255*** (0.088)	-0.005 (0.007)	-1.253*** (0.088)
Ln(<i>I</i>)	0.284*** (0.027)	0.002 (0.007)	0.284*** (0.027)	0.284*** (0.027)	0.006*** (0.002)	0.282*** (0.027)
Distance	0.016*** (0.004)	-0.008*** (0.001)	0.018*** (0.004)	0.016*** (0.004)	-0.001*** (0.0003)	0.016*** (0.004)
Scale	-5.3E-05 (0.0001)	0.0001*** (2.72E-05)	-7.3E-05 (0.0001)	-4.1E-05 (0.0001)	9.24E-06 (8.62E-06)	-4.5E-05 (0.0001)
School	-0.166** (0.074)	-0.087*** (0.018)	-0.153** (0.074)	-0.172** (0.074)	-0.001 (0.006)	-0.171** (0.074)
Organ	0.089*** (0.032)	0.051*** (0.008)	0.081** (0.032)	0.085*** (0.032)	0.001 (0.002)	0.085*** (0.032)
Democracy	0.036*** (0.007)	0.005*** (0.002)	0.036*** (0.007)	0.036*** (0.007)	-0.002*** (0.001)	0.037*** (0.007)
Constant	4.765*** (0.554)	-0.092 (0.133)	4.779*** (0.554)	5.515*** (0.516)	0.223*** (0.039)	4.259*** (0.528)
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
<i>R</i> ²	0.190	0.146	0.191	0.189	0.173	0.189
<i>No.</i>		4451			4422	
Sobel Test		-0.0003**			-0.001*	

Note: Estimation via the Structural Equation Model; standard error in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table9. The Effect of PHI on Happiness: Quantile regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	0.2Q	0.3Q	0.4Q	0.5Q	0.6Q	0.7Q	0.8Q
PHI	0.015 (0.012)	0.024** (0.012)	0.027** (0.011)	0.036*** (0.011)	0.036*** (0.010)	0.030*** (0.009)	0.032*** (0.010)
PHI ²	-0.0003 (0.0002)	-0.0004* (0.0002)	-0.0004** (0.0002)	-0.0006*** (0.0002)	-0.0006*** (0.0002)	-0.0005*** (0.0002)	-0.0006*** (0.0002)
Age	-0.052** (0.025)	-0.043* (0.024)	-0.036* (0.020)	-0.039* (0.023)	-0.041** (0.020)	-0.041** (0.017)	-0.031* (0.016)
Age ² /100	0.0008*** (0.0002)	0.0007*** (0.0002)	0.0006*** (0.0002)	0.0006*** (0.0002)	0.0006*** (0.0002)	0.0006*** (0.0002)	0.0005*** (0.0002)
Gender	0.058 (0.127)	-0.063 (0.124)	-0.097 (0.128)	-0.143 (0.115)	-0.219** (0.103)	-0.210** (0.091)	-0.244** (0.104)
Edu	0.051*** (0.017)	0.050*** (0.016)	0.058*** (0.016)	0.063*** (0.013)	0.045*** (0.011)	0.032*** (0.011)	0.026** (0.011)
Health ₁	-0.504*** (0.108)	-0.568*** (0.099)	-0.633*** (0.093)	-0.539*** (0.083)	-0.484*** (0.081)	-0.405*** (0.076)	-0.307*** (0.081)
Health ₂	-1.410*** (0.135)	-1.486*** (0.149)	-1.408*** (0.132)	-1.297*** (0.142)	-1.205*** (0.125)	-1.063*** (0.121)	-0.829*** (0.128)
Marriage	0.525*** (0.198)	0.492*** (0.200)	0.395** (0.174)	0.322** (0.158)	0.340** (0.140)	0.270* (0.138)	0.166 (0.138)
Ln(I)	0.463*** (0.051)	0.419*** (0.049)	0.396*** (0.047)	0.329*** (0.052)	0.255*** (0.038)	0.196*** (0.036)	0.150*** (0.036)
Distance	0.014** (0.007)	0.020*** (0.007)	0.019*** (0.006)	0.022*** (0.005)	0.019*** (0.004)	0.017*** (0.004)	0.016*** (0.003)
Scale	0.0001 (0.0002)	-1.1E-05 (0.0002)	1.37E-05 (0.0002)	-0.0001 (0.0001)	-0.0002* (0.0001)	-0.0003** (0.0001)	-0.0004*** (0.0001)
School	-0.154 (0.109)	-0.266** (0.111)	-0.103 (0.097)	-0.155* (0.092)	-0.154** (0.091)	-0.167* (0.088)	-0.180** (0.088)
Organ	0.085* (0.045)	0.129*** (0.046)	0.068* (0.040)	0.045 (0.038)	0.047 (0.038)	0.083** (0.037)	0.085** (0.037)
Democracy	0.044*** (0.016)	0.042*** (0.011)	0.040*** (0.010)	0.035*** (0.010)	0.032** (0.012)	0.036*** (0.014)	0.042*** (0.007)
Constant	1.148 (0.741)	1.990*** (0.705)	2.615*** (0.601)	3.769*** (0.617)	5.205*** (0.572)	6.229*** (0.512)	7.275*** (0.520)
PseudoR ²	0.146	0.146	0.124	0.096	0.081	0.105	0.097
Fixed effect	Yes						
No.	4451						

Note: Column (1)-(7) report the results of 0.2 to 0.8 quantile regression; *** p<0.01, ** p<0.05, * p<0.1.

Table10. The Effect of PHI on Happiness: Subsample Regression

	(1)	(2)	(3)	(4)	(5)	(6)
	Low Income	High Income	Unhealthy	Healthy	Unmarried	Married
PHI	0.010 (0.012)	0.036*** (0.010)	0.006 (0.012)	0.042*** (0.010)	-0.029 (0.031)	0.028*** (0.008)
PHI ²	-0.0002 (0.0002)	-0.0006*** (0.0002)	-0.0001 (0.0002)	-0.0007*** (0.0002)	0.001* (0.0005)	-0.0005*** (0.0001)
Age	-0.039 (0.023)	-0.043 (0.022)	-0.025 (0.028)	-0.051* (0.021)	-0.073 (0.039)	-0.039* (0.018)
Age ² /100	0.001** (0.0002)	0.0006** (0.0002)	0.0005* (0.0003)	0.0007*** (0.0002)	0.001* (0.0004)	0.0006*** (0.0002)
Gender	-0.175 (0.133)	-0.069 (0.105)	-0.215 (0.123)	-0.082 (0.110)	0.086 (0.300)	-0.137 (0.087)
Edu	0.056*** (0.015)	0.039** (0.012)	0.075*** (0.014)	0.030* (0.013)	0.026 (0.038)	0.052*** (0.010)
Health ₁	-0.476*** (0.109)	-0.430*** (0.084)			-0.395 (0.289)	-0.477*** (0.069)
Health ₂	-1.362*** (0.135)	-1.074*** (0.132)	-0.796*** (0.095)		-1.288** (0.388)	-1.256*** (0.097)
Marriage	0.065 (0.178)	0.649*** (0.173)	0.210 (0.167)	0.491** (0.177)		
Ln(I)	0.165*** (0.049)	0.357*** (0.057)	0.278*** (0.041)	0.280*** (0.046)	0.037 (0.133)	0.304*** (0.032)
Distance	0.014* (0.006)	0.016*** (0.005)	0.013 (0.007)	0.017*** (0.004)	0.006 (0.018)	0.018*** (0.004)
Scale	-0.0002 (0.0002)	4.74E-05 (0.0001)	0.0002 (0.0002)	-0.0003* (0.0001)	0.0002 (0.0005)	-6E-05 (0.0001)
School	-0.154 (0.120)	-0.167 (0.089)	-0.204 (0.106)	-0.097 (0.097)	-0.825** (0.318)	-0.116 (0.074)
Organ	0.064 (0.057)	0.112*** (0.03)	0.173*** (0.046)	0.038 (0.039)	-0.065 (0.145)	0.109*** (0.030)
Democracy	0.042*** (0.012)	0.030* (0.012)	0.048*** (0.013)	0.025* (0.012)	0.086* (0.035)	0.035*** (0.009)
Constant	5.460*** (0.727)	3.532*** (0.776)	3.597*** (0.826)	4.115*** (0.629)	7.070*** (1.567)	4.403*** (0.518)
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
No.	2071	2380	2306	2145	337	4114
R ²	0.165	0.182	0.183	0.142	0.268	0.198

Note: Dependent variable is happiness; in column (5), although the square term is significantly positive, the PHI cannot reject the null hypothesis, indicating that it increases in the definitional domain; heteroskedasticity robust standard error in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table11. The Effect of PHI on the Elderly's Happiness

	(1) Age $\geq$ 50	(2) Age $\geq$ 55	(3) Age $\geq$ 60	(4) Age $\geq$ 65
PHI	0.024** (0.010)	0.031*** (0.012)	0.013 (0.015)	0.039* (0.022)
PHI ²	-0.0004** (0.0002)	-0.0006*** (0.0002)	-0.0003 (0.0002)	-0.0006* (0.0004)
Age	0.082 (0.066)	0.130 (0.112)	0.325* (0.193)	-0.026 (0.319)
Age ² /100	-0.0003 (0.0005)	-0.0007 (0.0008)	-0.002 (0.001)	0.0003 (0.002)
Gender	-0.076 (0.135)	0.003 (0.173)	0.115 (0.227)	0.271 (0.298)
Edu	0.051*** (0.012)	0.041*** (0.014)	0.029* (0.017)	0.054** (0.025)
Health ₁	-0.44*** (0.087)	-0.409*** (0.101)	-0.487*** (0.124)	-0.524*** (0.181)
Health ₂	-1.174*** (0.115)	-1.149*** (0.126)	-1.166*** (0.147)	-1.236*** (0.203)
Marriage	0.190 (0.174)	0.242 (0.196)	0.015 (0.219)	0.022 (0.288)
Ln(I)	0.235*** (0.040)	0.227*** (0.045)	0.206*** (0.053)	0.243*** (0.091)
Distance	0.0183*** (0.005)	0.016*** (0.006)	0.017** (0.007)	0.020** (0.009)
Scale	-2.4E-07 (0.0001)	0.0001 (0.0002)	0.0001 (0.0002)	0.0002 (0.0003)
School	-0.158* (0.095)	-0.176 (0.112)	-0.093 (0.135)	-0.314 (0.193)
Organ	0.144*** (0.040)	0.148*** (0.051)	0.138** (0.064)	0.108 (0.089)
Democracy	0.038*** (0.014)	0.032* (0.017)	0.038** (0.018)	0.012 (0.023)
Constant	1.028 (2.097)	-0.612 (3.710)	-6.913 (6.612)	5.416 (11.62)
Fixed Effect	Yes	Yes	Yes	Yes
R ²	0.201	0.206	0.210	0.240
No.	2433	1753	1206	639

Note: Dependent variable is happiness; heteroskedasticity robust standard error in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Fig.1 The Trend of Rural Residents' Happiness(2011-2016)

Fig.2 The Trend of Rural Residents' Happiness from CGSS(2003-2013)

Fig.3 Generalized Propensity Score Matching.