Health cost risk, informal insurance, and annuitization decisions

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Abstract: This paper provides the first piece of empirical evidence regarding the impact of health cost risk on individuals' annuitization decisions. We find that health cost risk increases the probability of individuals' pension participation but decreases the amount of pension contributions. We show that the substitution effect of informal insurance on pensions leads to these seemingly contradictory results. The impact of health cost risk on pension participation and contributions is negative and consistent with the mainstream theory after accounting for the effect of informal insurance. The substitution effect of informal insurance on pensions is stronger, and thus mitigates the impact of health cost risk more pronounced for households that have better-educated children, lower incomes, and more informal social networks and in regions that have a higher male–female ratio, that have higher mobility, or are less developed; but this substitution effect does not differ depending on their children's gender. This study improves our understanding of the relationship between health cost risk and individuals' annuitization decisions as well as the role of informal insurance in this relationship.

Keywords: Health cost risk**,** Pension decision, Informal insurance, Annuity puzzle

JEL Code: D81, G52, H55

1. Introduction

The annuity puzzle has long been a central topic in household finance (Ameriks et al., 2011; Inkmann, Lopes and Michaelides, 2011). The classical annuity demand theory suggests that people should fully annuitize their savings if during the annuitization decision process they have no bequest motives and the length of their lives is the only uncertainty (Yaari, 1965). However, elderly people annuitize little of their wealth, if any, to address the longevity risk of outliving their income (Benartzi, Previtero and Thaler, 2011). The theory of health cost risk provides a potential explanation for the empirically observed annuity puzzle. Specifically, this theory states that health risks and their associated costs motivate individuals to keep precautionary liquidity for out-of-pocket health-related expenditures, which decreases their annuity demand in the early retirement years (Davidoff, Brown and Diamond, 2005; Turra and Mitchell, 2008; Peijnenburg, Nijman and Werker, 2017).

The existing theoretical models and simulations do not reach a consensus when considering the impact of health cost risk on annuitization decisions. Previous studies suggest that the impact of health cost risk on annuity demand in the early retirement years could be negative (see e.g., Davidoff, Brown and Diamond, 2005; Peijnenburg, Nijman and Werker, 2017), positive (Pang and Warshawsky, 2010), or parameter-sensitive (Pashchenko, 2013). The optimal annuitization decision depends on the timing of the health cost risk and on the availability of alternative assets. On the one hand, uninsured medical expenditures early in life reduce the value of the annuities when compared to alternative assets (e.g., bonds), and thus leads to a lower optimal annuitization level than that later in life (Davidoff, Brown and Diamond, 2005; Peijnenburg, Nijman and Werker, 2017). On the other hand, health spending risk may also drive household portfolios to shift from risky equities to safer assets (e.g., bonds, annuities), while annuities may eventually dominate bonds due to the embedded survivorship premium that increases with age (Pang and Warshawsky, 2010). Therefore, real-world empirical evidence is necessary to examine and harmonize the diverse theoretical predictions and rationales.

There are two primary reasons for the lack of empirical evidence examining the impact of health cost risk on annuitization decisions. First, it is difficult to measure health cost risk in countries with a comprehensive health insurance system, for example, those in Europe, where out-of-pocket health costs are negligible (Peijnenburg, Nijman and Werker, 2016) and therefore hardly motivate individuals' liquidity needs. Health cost risk is, however, prominent in developing countries with immature health insurance systems. Second, it is difficult to empirically disentangle health cost risk from longevity risk, as an unexpected health shock in the future induces high medical expenses (i.e., health costs) and simultaneously affects longevity risk.

China's Residents' Basic Pension (RBP) program provides an ideal setup for empirically analyzing the annuity puzzle because the RBP program mimics the assumption that the individual has no bequest motive and the prediction that the individual will fully annuitize, as suggested in Yaari (1965). Under the RBP program, the individual-account pension benefits are financed by individual contributions in the heritable, fully funded individual accounts; the general account basic pension benefits are financed purely by the general tax on a pay-as-you-go basis. Therefore, the RBP program has two unique features: (i) the individual's decision on whether to participate is independent of the bequest motives because all individual contributions to the program are heritable and free of inheritance tax, which is equivalent to savings; and (ii) all rational eligible individuals should participate, given the level of the general tax subsidy (i.e. the government matching contributions to the general account) and their longevity risk considerations.

The RBP program was initiated in rural China in 2009, expanded to the urban areas in 2011, and became available to all eligible residents in 2012. As most eligible residents had no annuity access before the RBP program, its introduction enables us to observe their clear-cut annuitization decisions. Unlike other pension programs, RBP-eligible residents only make their annuitization decisions when they decide to participate in the voluntary program. Residents in our sample are those not covered by the compulsory Employees' Basic Pension (EBP),[1] that is the informal sector residents, such as farmers, unemployed residents, and workers in flexible employment, who are therefore sensitive to health costs. The public health insurance for informal sector residents in China requires high copayments,[2] and its scope of coverage is narrow (Yip et al., 2012). The public long-term care insurance system largely did not exist during our sample period.[3] Therefore, the out-of-pocket health cost risk is expected to be prominent for individuals in our sample.

In addition, we empirically disentangle the impact of longevity risk from that of health cost risk

[1] The public pension system in China has two schemes: the EBP and the RBP. The EBP is compulsory for employees in the formal sector (i.e., government, public institutions, and formally established enterprises), while the RBP is voluntary and targets residents who are not covered by the EBP.

[2] The reimbursement rate of hospitalization expenses is 75%; the rate for out-patient expenses is much lower than 75% and depends on provinces and cities (China State Council, 2016).

[3] The public long-term care insurance pilot programs started in 15 cities and two provinces in 2016.

on pension decisions using a unique dataset. We identify longevity risk by considering the self-estimated likelihood to live beyond 75 years old, as captured by the China Health and Retirement Longitudinal Study (CHARLS). This measure isolates an individual's life expectancy from her health cost risk. We use the self-reported health status, the number of chronic diseases, and the projected health risk five years in the future to approximate an individual's health cost risk. The self-reported health status and the self-estimated life expectancy are ideal measures to capture health cost risk and longevity risk respectively because they are the subjective beliefs, upon which individuals make their annuitization decisions (Post and Hanewald, 2013; Yogo, 2016).

This paper analyzes individuals' annuitization decisions based on the introduction of the RBP program and empirically verifies the health cost risk explanation to the annuity puzzle. Using nationally representative longitudinal data from China, we find that individuals in good or fair health have a lower probability, by 2.00 and 1.70 percentage points, respectively, of participating in the RBP program compared with individuals in poor health. Having one more chronic disease increases the probability of participating in the RBP by 0.49 percentage points. A one percentage point increase in predicted health risk in five years increases the probability of participating in the RBP by 0.048 percentage points. To the contrary, when compared with RBP participants in poor health, participants in fair and in good health contribute 2.9% and 10.5% more to the RBP program, respectively. Having one more chronic disease decreases the contributions of RBP participants by 0.94%. A one percentage point increase in predicted health risk in five years decreases the contributions of RBP participants by 0.13%.

We use informal insurance to explain the above contradiction between the impacts of health cost risk on pension participation and on pension contributions. We approximate informal insurance by the number of children in a household and by whether parents rely on their children for old age support (Rossi and Godard, 2022). Teasing out the effect of informal insurance, we find that compared with individuals with higher health cost risk, individuals with lower health cost risk are more likely to participate in pensions and contribute more after enrollment when they have no informal insurance (i.e., they have no child), which aligns with the mainstream theoretical predictions (Davidoff, Brown and Diamond, 2005; Peijnenburg, Nijman and Werker, 2017). It is the substitution effect of informal insurance on pensions that leads to the seemingly opposite impact of health cost risk on pension participation and contributions, and this substitution effect is larger among the healthier individuals.

The substitution effect of informal insurance on pensions mitigates the impact of the health cost risk on annuitization decisions. In terms of the pension participation decisions, having two or more children can offset the positive impact of fair or good health on pension demand; in terms of the pension contribution decisions, having four or more children can offset the positive impact of fair or good health on pension demand.

We further show that the substitution effect of informal insurance on pensions is stronger, and thus mitigates the health cost risk impact more pronounced, among households that have better-educated children, lower incomes, and more informal social networks and those in regions that have a higher male–female ratio, that have higher mobility, or are less developed. We find that the gender of the individuals' children does not yield different effect on pension substitution. We rule out income and property ownership as explanations for the opposite impact of the health cost risk on the intensive and extensive margins of pension demand. Our results emphasize the importance of informal insurance when analyzing the impact of health cost risk on individuals' annuitization decisions, especially in developing economies with inadequate health insurance coverage and a large health protection gap.

Contributions and Relationship to Literature -- Our paper contributes to the literature in two ways. First, we contribute to the understanding of the annuity puzzle and the impact of health cost risk on annuitization decisions. Recent theoretical works considering health cost risk find that partial or no annuitization can be the optimal level (Davidoff, Brown and Diamond, 2005; Reichling and Smetters, 2015). An uninsured health cost risk early in life reduces the value of annuities when compared with alternative assets (e.g., bonds), if it is not possible to sell or borrow against the future payments of the fixed annuity stream while it is possible to do so for the alternative assets (Davidoff, Brown and Diamond, 2005). However, if uncertain health expenses occur later in life, individuals can annuitize all wealth and save money out of the annuity income to build a liquid wealth buffer against the risk (Ai et al., 2017; Peijnenburg, Nijman and Werker, 2017). In contrast, Pang and Warshawsky (2010) suggest that there is a positive impact of the health spending risk on annuity demand. Pashchenko (2013) finds that uncertain medical expenses, which are a type of health cost risk, have a very small effect on annuity ownership and the direction of the effect depends on parameters.

To the best of our knowledge, no empirical work has examined the inconsistent theoretical predictions regarding the impact of the health cost risk on annuitization decisions. Our paper fills the gap by providing the first piece of the empirical evidence.

Second, our paper contributes to the literature on informal insurance and its substitution effect on pensions. Informal insurance provided by households and other types of social networks is prevalent in developing economies (Bu and Liao, 2022), where the formal public/private insurance system is underdeveloped (Bloch, Genicot and Ray, 2008; Oliveira, 2016). The demand for social insurance depends on the availability of informal insurance (Bloch, Genicot and Ray, 2008). It is common for couples to have and raise children with a motive of ensuring their security in old age. Children are an important income source in the sense of a family transfer to their parents. Altruism and trust within a household ameliorate the commitment constraints and reinforce the risk-sharing agreements within a household, which forms a potential informal insurance provider and substitutes for a large fraction of the pension scheme (Kotlikoff and Spivak, 1981; Foster and Rosenzweig, 2001; Eugster et al., 2011). Having more children to support the parents in elderly life provides a more adequate and reliable hedge against longevity risks (Oliveira, 2016) and thus reduces the demand for annuities.

To the best of our knowledge, the existing literature only considers bequest motives but neglects the role of informal insurance as a substitute for pensions when analyzing the role that children play in the impact of health cost risk on annuitization decisions (Davidoff, Brown and Diamond, 2005; Pang and Warshawsky, 2010; Panshchenko, 2013; Reichling and Smetters, 2015). This paper is the first to examine the pension substitution role that informal insurance plays in the relationship between health cost risk and annuitization decisions.

The rest of the paper is structured as follows. Section 2 introduces the institutional background. Section 3 describes the data and methodology. Section 4 reports our main empirical results. Section 5 conducts additional analyses on the informal insurance's impact. Section 6 rules out the alternative explanations and discusses the robustness of the results. Section 7 concludes.

2. Institutional background

Children's responsibility within a household is often an important part of old-age support, especially in developing countries. Many countries, for example, Bangladesh, India, and Singapore, have filial support laws (Serrano, Saltman and Yeh, 2017). The Marriage Law in China codifies the obligation of support from adult children to their elderly parents; the Confucian tradition requires the same. These laws and traditional culture result in a strong informal old-age security system, especially in rural China (Giles, Wang and Zhao, 2010).

The RBP program is the largest public pension program in China. All rural and urban residents aged 16 or above, who are not in school/university and who are not in the compulsory EBP, are eligible to voluntarily participate in the RBP. Participation in and contributions to the RBP program are at the individual level. Upon an individual's death, 100% of the individual account balance can be inherited by designated heirs. The RBP does not provide spousal benefits. Thus, the decisions whether to participate in and contribute to the RBP are free of bequest motives and survivor benefit considerations. Furthermore, RBP contributions *cannot* be withdrawn or borrowed against to pay for medical expenses in either the pre-retirement contribution period or the post-retirement benefit period.

The RBP is a partially funded system. Annual individual contributions are saved in individual accounts and accumulated until retirement to pay for the "individual account pension benefits" (i.e., the fully funded component). The provincial government sets several amount options for the annual individual contributions, which ranged from CNY 100 to CNY 9,000 during our sample period. Higher individual contributions are usually matched by a higher premium subsidy from local governments into the individual account, with the goal of motivating residents to contribute more. The monthly individual account pension benefits are equal to the account balance at retirement divided by 139, that is, the division factor determined by the average remaining months of life at the retirement age of 60.

The RBP has another component called the "general account basic pension benefits" (i.e., the pay-as-you-go component), which is paid for through a general tax. The monthly benefits are set by each province and ranged from CNY 55 to CNY 930 during our sample period. The general account basic pension benefits are much higher in eastern provinces than in middle and western provinces due to economic development differences between the areas. For example, in 2018, retired residents in Shanghai received CNY 930 monthly RBP basic pension benefits, and the amount in Beijing was CNY 610, but in most middle and western provinces, the amount was CNY 88. Given the variation in the general tax funded pension benefits (i.e., the "free" basic pension benefits), it is financially beneficial and attractive for all eligible residents in China to participate in the RBP.

To receive RBP pension benefits, participants must be at least 60 years old and have contributed for at least 15 years to the RBP scheme. Exceptions are made for participants who were already 60 years old or older, or had less than 15 years before turning age 60 at the time the RBP was introduced to his/her province. These older participants are entitled to receive pension benefits immediately without any contribution if they are 60 or older and if their eligible adult children have enrolled in the

RBP scheme, or they contribute until age 60 and then receive pension benefits.[4] Hence, the residents who were 60 years old or older when the RBP was introduced to his/her province did not make a pension participation decision.

The RBP arose from the merger of two public pension schemes in 2014: the New Rural Basic Pension and the Urban Residents' Basic Pension. The former was launched in 2009 to cover all rural residents, while the latter was launched in 2011 to cover urban residents who were not covered by the EBP. There were few differences in the rules of these two short-lived public pension schemes. Thus, we consider them as one RBP program in our analyses and control for the urban or rural registered residence, wherever applicable.

3. Data and methodology

3.1 Empirical design

Health is one of the most important determinants of an individual's financial portfolio choice (Rosen and Wu, 2004) and consumption decisions (Smith and Keeney, 2005). Longevity risk and health cost risk are the predominate risks that the elderly face concerning optimal financial security in retirement (Peijnenburg, Nijman and Werker, 2017). Longevity risk can be hedged by annuities or a pension that provides a stable stream of income for the elderly until death. Health cost risk, as suggested by the precautionary saving theory, motivates liquidity needs and thus decreases annuity demand, which is an important explanation for annuity puzzle (Davidoff, Brown and Diamond, 2005; Turra and Mitchell, 2008; Peijnenburg, Nijman and Werker, 2017). However, there is no empirical evidence regarding how health cost risk affects pension demand. To answer this question, we construct the baseline model as follows:

$$\begin{aligned} Pension\_demand_{it} &= \beta_0 + \beta_1 Health\_cost\_risk_{it} + \beta_2 Longevity\_risk_{it} \\ &+ \beta_3 Informal\_insurance_{it} + \boldsymbol{\lambda X_{it}} + \delta Year_t + \gamma Province_i + \varepsilon_{it}, \end{aligned} \quad (1)$$

[4] Individuals could also decide not to participate at the time RBP was introduced but change their mind and participate at a later stage. Individuals choosing that option would have to contribute for a minimum of 15 years or the difference

where the subscripts *i* and *t* represent the individuals and survey waves, respectively. $Pension\_demand_{it}$ is measured by: (i) whether individual *i* participated in the RBP scheme in year *t* (*Pension_participation*), and (ii) the contributions that individual *i* paid to the RBP program in year *t* (*Pension_contribution*). We estimate Eq. (1) with a Probit model for the dummy dependent variable *Pension_participation* based on the full sample (i.e., the extensive margin). We estimate an OLS regression for the log form continuous dependent variable Ln(*Pension_contribution*)[5] on a subsample of RBP participants (i.e., the intensive margin).

$Health\_cost\_risk_{it}$ is captured by: (i) individual *i*'s self-reported health status in year *t*, (ii) individual *i*'s number of chronic diseases in year *t*, and (iii) individual *i*'s projected health risk five years in the future. We use these measures for three primary reasons. First, there is a significant correlation between health status and the probability of incurring out-of-pocket medical expenditures (Turra and Mitchell, 2008). Second, future health status can accurately be predicted by the present health status (Yogo, 2016), which can be captured by a self-reported health status and the number of chronic diseases. Third, according to Peijnenburg, Nijman and Werker (2017), health cost risk after approximately five years has little impact on the annuitization decision. Hence, we use five years as a threshold to project future health cost risk.

$Longevity\_risk_{it}$ is captured by individual *i*'s self-estimated likelihood of living beyond 75 years of age in year *t*.[6] The age of 75 years old is an ideal threshold given that the Chinese life expectancy was 74.83 years old in 2010. The subjective longevity measure is better than any objective mortality measures because individuals make their annuitization decisions based on their perception of their own longevity risk.

We measure $Informal\_insurance_{it}$ by: (i) the living number of children of individual *i* in year *t* (*Number_of_children*), and (ii) as a robustness test, whether an individual relies on his/her children for retirement (*Rely_on_children*). We do not use family transfer to measure informal insurance because

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between the introduction year and the year the individual reached age 60, whichever is smaller. Individuals are also allowed to make a lump sum pension contribution as long as the cumulative payments did not exceed 15 years' worth of contributions. Such a lump sum contribution is higher than the sum of the annual contributions due to the lack of subsidies that are matched to their annual contributions.

[5] We generate the log form continuous variables in this paper based on the equation "Ln(*x*)=ln(*x*+1)" when *x* is positive and the equation "Ln(*x*)=-ln(-*x*+1)" when *x* is negative.

[6] All respondents under 65 years old were asked "Suppose there are 5 steps, where the lowest step represents the smallest chance and the highest step represents the highest chance. On what step do you think is your chance in reaching the age of 75?"

our sample consists of individuals who are between 45 and 59 years old and are still working, whose children are at school/university or in an early stage of their careers and most likely have not yet started to transfer income to their elderly parents. Using the number of children to measure informal insurance follows the conventional wisdom of raising children for old-age support (Rossi and Godard, 2022). Children might also be a burden to their elderly parents if the children are not financially independent and continue to rely on their parents after they have grown; this may affect the elderly parent's financial portfolio decisions. Therefore, we use the *Rely_on_children* as an alternative informal insurance measure, which captures an individual's subjective beliefs about the possibility to rely on their children for old-age support.

$\boldsymbol{X_{it}}$ is a vector of control variables representing age, gender, ethnicity, marital status, education, risk attitude, health insurance status, wealth, urban/rural residence, and life satisfaction. We include the province fixed effects, as the policy of the RBP program and its accumulated funds were managed at the provincial level.[7] We also include year fixed effects.

To examine whether and to what extent the substitution effects of child-provided informal insurance on pensions mitigates the impact of health cost risk on pension demand, we include an interaction term between $Informal\_insurance_{it}$ and $Health\_cost\_risk_{it}$, as shown in Eq. (2).

$$\begin{aligned} Pension\_demand_{it} &= \alpha_0 + \alpha_1 Health\_cost\_risk_{it} \\ &+ \alpha_2 Longevity\_risk_{it} + \alpha_3 Health\_cost\_risk_{it} \times Informal\_insurance_{it} \\ &+ \alpha_4 Informal\_insurance_{it} + \boldsymbol{\theta X_{it}} + \delta Year_t + \gamma Province_i + \varepsilon_{it}. \end{aligned} \tag{2}$$

To reveal the mechanism and heterogeneity of informal insurance's substitution effect on pensions, we estimate Eq. (2) in several subsamples in relation to children's characteristics (including children's education, children's gender), annuitization decision-makers' characteristics (including income level and informal social networks), and regional characteristics (including regional male–female ratio, mobility, and development levels).

[7] We identify the between-group variation, that is, the difference in pension demand between individuals with different health statuses. We do not identify the within-group variation by estimating individual fixed effects because the sample is heavily unbalanced. Specifically, there are 14,324 individual-year observations for 8,552 individuals. Hence, some individuals appear only once in our sample.

3.2 Data and sample

Our data are obtained from the China Health and Retirement Longitudinal Study (CHARLS). CHARLS belongs to the family of well-established international health and retirement surveys, including, for example, the Health and Retirement Study (HRS) in the United States and the Survey of Health, Ageing, and Retirement in Europe (SHARE). CHARLS is nationally representative and involves surveying respondents aged 45 years and older from 450 villages or urban communities from 150 counties or urban districts in China. The national baseline survey was conducted in 2011; this was followed up with surveys in 2013, 2015, and 2018. The latter waves revisit the same respondents as in the baseline survey and recruit new age-eligible respondents to maintain a representative sample (Zhao et al., 2020). Interviews ask respondents about their personal information, family structure and family financial support, health status, work, income and assets, and retirement and pension plans, among other things. CHARLS has been widely used in the finance and economic research published in leading academic journals (e.g., Oliveira, 2016; İmrohoroğlu and Zhao, 2018; Cui, Smith and Zhao, 2020).

Using CHARLS (2011–2018), we construct our sample in the following steps. First, we select respondents who are between 45 and 59 years old and who are eligible to participate in the RBP scheme. CHARLS specifically targets survey respondents aged 45 and older; respondents who are age 60 or older in the survey year should have already been receiving pension benefits and therefore do not need to make pension decisions. Second, we exclude observations with missing variable values. The final sample for our baseline analyses contains 14,324 individual-year observations. Our sample size is comparable to that of relevant studies using CHARLS (see e.g., Oliveira, 2016; Cui, Smith and Zhao, 2020).

Table 1 presents the summary statistics for our sample. *Pension_participation* is a dummy variable that equals 1 when individuals participated in the RBP program, and 0 when an eligible individual did not participate.[8] *Pension_contribution* is a continuous variable representing the annual contributions that individuals paid to the RBP program. Three dummy variables are used to capture

[8] There are a small number of individuals in our sample reported participating in the RBP in earlier surveys (*Pension_participation* = 1) but not participating in later surveys (*Pension_participation* = 0). These individuals stopped pension contributions. They could resume the contribution in later years or give up their general account basic pension benefits as their contributions are less than 15 years.

the individual's self-reported health status: *Health*^{poor}, *Health*^{fair}, or *Health*^{good}. *Health*^{poor} equals 1 when the self-reported health status is very poor or poor, and 0 otherwise. *Health*^{fair} equals 1 when the self-reported health status is fair, and 0 otherwise. *Health*^{good} equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with.[9] *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years.[10]

[Table 1 here]

Three dummy variables are used to capture the individual's longevity risk: *Unlikely_75*, *Maybe_75*, and *Likely_75*. *Unlikely_75* equals 1 when the individual evaluates his/her chances of reaching the age of 75 as almost impossible or not very likely, and 0 otherwise. *Maybe_75* equals 1 when the individual evaluates his/her chances of reaching the age of 75 as maybe, and 0 otherwise. *Likely_75* equals 1 when the individual evaluates his/her chances of reaching the age of 75 as very likely or almost certain, and 0 otherwise. *Number_of_children* is the number of the individual's living children. *Rely_on_children* equals 1 when the individual expects children to be his/her main financial resource in old-age, and 0 when the individual expects savings, public or private pensions, or other financial resources as the main financial resource for old age.

Regarding the control variables, *Age is* the individual's age. *Male* equals 1 when the individual is male and 0 when female. *Minority* equals 1 when the individual is in a minority ethnic group and 0 when the individual is in the majority ethnic group (*Han*). *Married* equals 1 when the individual is married, and 0 otherwise. Three dummy variables are used to capture the education level.

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[9] Chronic diseases, defined in the CHARLS questionnaires, include: (i) hypertension, (ii) dyslipidemia, (iii) diabetes or high blood sugar, (iv) cancer or malignant tumor(s), (v) chronic lung diseases (e.g., chronic bronchitis, emphysema), (vi) liver disease, (vii) heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems, (viii) stroke, (ix) kidney disease, (x) stomach or other digestive disease, (xi) emotional, nervous, or psychiatric problems, (xii) memory-related disease, (xiii) arthritis or rheumatism, and ivx) asthma.

[10] *Health_risk* is the predicted probability of individual *i* being in poor health in five years or deceased within five years. We use an individual's health status in 2018 (2015) to approximate his/her future health status when in 2013 (2011). The covariates of the regression for prediction follow Peijnenburg, Nijman and Werker (2017)'s model to estimate the health transition matrix. We chose to use current income instead of permanent income because our sample comprises individuals aged 45–59 years, most of whom are still in the labor force, while Peijnenburg, Nijman and Werker (2017)'s sample was solely comprised of retired individuals. We also add a dummy in the regression to indicate one year less because the difference between 2011 and 2015 is four years. We then use the estimated coefficients to predict individuals' *Health_risk* in five years for each wave in our sample.

$Education^{illiterate}$ equals 1 when the individual has no formal education or is illiterate, and 0 otherwise. $Education^{elementary}$ equals 1 when the individual has not finished primary school but is capable of reading and/or writing, has attended a home school, or graduated from elementary school, and 0 otherwise. $Education^{middleabove}$ equals 1 when the individual has completed a middle school education or higher levels of schooling, and 0 otherwise. Wakker, Timmermans and Machielse (2007) emphasize the importance of risk attitude to insurance decisions. An individual's investment in preventive health care has often been used to capture the individual's risk attitude (de Meza and Webb, 2001; Finkelstein and McGarry, 2006). We follow the practice by using *Physical_exam* to capture an individual's risk attitude. *Physical_exam* equals 1 when the individual has taken a physical examination within the past two years, and 0 otherwise. *Health_insurance* equals 1 when the individual has public health insurance, and 0 if he/she does not.[11] *Wealth* measures the household wealth per capita. *Urban* equals 1 when the individual's registered residence (*hukou*) is urban, and 0 when the individual's registered residence is rural. Three dummy variables are used to capture the individual's life satisfaction: $Life^{unsatisfied}$, $Life^{somewhat\_satisfied}$, and $Life^{satisfied}$. $Life^{unsatisfied}$ equals 1 when the individual feels "not at all satisfied" or "not very satisfied" with his/her life, and 0 otherwise. $Life^{somewhat\_satisfied}$ equals 1 when the individual feels "somewhat satisfied" with his/her life, and 0 otherwise. $Life^{satisfied}$ equals 1 when the individual feels "very satisfied" or "completely satisfied" with his/her life, and 0 otherwise.

Regarding the variables related to the subsamples, $Education^{advanced}_{children}$ equals 1 when the individual's children have an advanced education (i.e., two or three years of college or an associate's degree or higher levels of schooling), and 0 otherwise.[12] *Number_of_sons* and *Number_of_daughters* are the number of the individual's living sons and living daughters, respectively. $Income^{high}$ equals 1 when the individual's income is equal to or above the median income level in the sample, and 0 otherwise. *Informal_social_networks* equals 1 when the individual has one or more informal social networks,[13]

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[11] Public health insurance includes urban resident medical insurance, new cooperative medical insurance, and urban and rural resident medical insurance. Public health insurance is the only accessible health insurance program for almost all individuals in our sample. The decisions to participate in public health insurance and RBP are independent of each other as they are operated by different institutions.

[12] The education of the younger generation has greatly improved. Accordingly, we classify the educational levels of parents and children using different categories.

[13] Informal social networks, defined in CHALRS, include: (i) interacting with friends; (ii) playing ma-jong, playing chess, playing cards, or going to a community club; (iii) providing help to family, friends, or neighbors who do not live with you; (iv) going to a sport, social, or other kind of club; (v) taking part in a community-related organization; (vi) conducting voluntary or charity work; (vii) caring for a sick or disabled adult who does not live with you; (viii) attending an educational or training course; (ix) making a stock investment; (x) using the internet; and (xi) others.

and 0 when the individual has none of the informal social network. $Male\_female\_ratio^{high}$ equals 1 when the region's male–female ratio is equal to or greater than the median male–female ratio for all provinces in China's mainland, and 0 otherwise. $Regional\ mobility^{high}$ equals 1 when the proportion of registered residents working outside the village or community for more than three months is equal to or greater than 10%, and 0 otherwise. *Eastern_provinces* equals 1 when the individual's registered residence is among the 11 eastern provinces in China,[14] and 0 otherwise. *Labor_income* is the sum of the individual's wage income, individual-based transfers, net agricultural income per capita, net livestock income per capita, and net income from self-employed activities per capita. *Rental_income* is income from a house/apartment and/or land rent per capita. *Net_income* includes *Labor_income*, *Rental_income*, and household public transfer income per capita. *Property_ownership* equals 1 when the individual owns land (including collective distributing cultivated land, forest land, pasture, and pond) or a house/apartment, and 0 otherwise. *Living_parent* equals 1 when the respondent has at least one living parent (i.e., biological father, biological mother, stepfather, or stepmother), and 0 otherwise.

Table 1 shows that the average RBP participation rate is 79% over the four waves of surveys during 2011–2018. The high participation rate is driven by heavy general tax subsidies (i.e. government matching funds) to the RBP program that makes the RBP financially attractive to eligible residents. The average annual contribution is CNY 254.1 if including nonparticipants, while it is CNY 323.5 for the RBP participants. In our sample, 24% of individuals are in poor health, 50% are in fair health, and 26% are in good health. The average number of chronic diseases is 1.47 per person, given the age range of 45 to 59. The average probability of being in poor health or deceased in five years is 25%; 29% of individuals believe that they will not live until 75 years old, 39% think they may, and 32% think it is likely. On average, there are 2.24 living children of an individual in our sample, and 73% of respondents think they can financially rely on their children during their old age, suggesting that senior and middle-aged Chinese follow the conventional wisdom of raising children for old-age support.

Overall, the average age of the respondents is 52.5, 47% are male, 11% belong to an ethnic minority, and 95% are married. In terms of educational levels, 16% of respondents are illiterate, 43% have an elementary school education, and 41% have a middle school education or above. Thirty-five percent of respondents have taken at least one physical examination within the past two years, and 96%

[14] The 11 eastern provinces are Beijing, Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan.

are covered by public health insurance, which is consistent with the officially announced high participation rate. The average household wealth per capita is CNY 127 thousand. Only 7.0% of respondents have an urban registered residence because a large fraction of urban residents is covered by the EBP, and therefore, are ineligible for the RBP. Fourteen percent of individuals are not satisfied with their lives, 56% are somewhat satisfied, and 30% are satisfied.

The educational levels of the younger generation are much higher than that of the senior and middle-aged respondents in our sample: Thirty-one percent of respondents' children have completed an advanced education (including an associate's degree, a bachelor's degree, a master's degree, or a doctoral degree). On average, there are 1.18 living sons and 1.07 living daughters of a respondent in our sample. Fifty-eight percent of the respondents have informal social networks, 45% of respondents live in high male–female ratio provinces, 67% live in high-mobility regions, and 32% live in eastern provinces. The individual average annual net income, labor income, and rental income are CNY 9191.4, CNY 8203.4, and CNY 237.6, respectively. Ninety-eight percent of respondents own land and/or houses/apartments.[15] Sixty-eight percent of respondents have at least one living parent.

4. Empirical results

4.1 Impact of health cost risk on pension demand

Table 2 presents the results of Eq. (1), which represents the impact of health cost risk on pension demand. Columns (1)–(3) use the full sample to estimate the impact on pension participation (i.e., the extensive margin). Columns (4)–(6) use the sample of pension participants to estimate the impact on pension contributions (i.e., the intensive margin). We report the average marginal effects of the Probit regressions and the coefficients of the OLS regressions. We estimate robust standard errors in our main results.

[Table 2 here]

The results in Columns (1)–(3) of Table 2 show that pension participation increases with the health cost risk when controlling for the longevity risk. When compared with individuals in poor health,

[15] In CHALRS, 78.8% of respondents own land and 94% of respondents own houses/apartments.

individuals in fair or good health have a 1.70 and 2.00 percentage points lower probability of participating in the RBP, respectively. Having one more chronic disease increases the probability of participating in the RBP by 0.49 percentage points. A one percentage point increase in projected health risk in five years increases the probability of participating in the RBP by 0.048 percentage points. The result contradicts the precautionary savings theory for health cost risk, which predicts that optimal annuitization levels are lower for individuals in poor health than those in good health (Davidoff, Brown and Diamond, 2005; Turra and Mitchell, 2008; Ai et al., 2017; Peijnenburg, Nijman and Werker, 2017).

The results in Columns (4)–(6) illustrate that the contributions of RBP participants decreases with the health cost risk, which is the opposite result of the pension participation analyses. When compared with participants in poor health, participants in fair health and those in good health contribute 2.87% and 10.5% more to the RBP program, respectively. Having one more chronic disease decreases the contributions of RBP participants by 0.94%. A one percentage point increase in projected health risk in five years decreases their contributions of the RBP participants by 0.13%. The results are consistent with the mainstream theoretical assertion that a health cost risk early in retirement increases the need for liquidity, and thus, lowers the annuity demand (Davidoff, Brown and Diamond, 2005; Turra and Mitchell, 2008; Ai et al., 2017; Peijnenburg, Nijman and Werker, 2017).

The longevity risk always has a positive impact on pension demand for both pension participation and pension contributions. As a robustness test, we estimate the impact of health cost risk on pension contributions, including both the pension participants and the nonparticipants in the full sample. The results show that the coefficients on the health cost risk become smaller or insignificant, suggesting that the effect of the intensive margin and that of the extensive margin offset each other (see Section 6.2).

In sum, we document the opposite impacts of health cost risk on pension demand when individuals decide whether to participate in the pension program (i.e., pension participation) and when they determine how much to contribute (i.e., the extent of participation or pension contribution) after they have enrolled in the pension program.

4.2 Substitution effect of informal insurance on pensions

The existing theoretical work has yet to explain the seemingly contradictory results that show health cost risk increases the probability of pension participation but decreases the amounts of pension contributions. In this paper, we consider children as alternative informal insurance to pensions for old-age security (Rossi and Godard, 2022), as children provide financial, physical, and emotional support to the elderly. Given that participation and contributions to the RBP scheme is free of bequest motives, we are able to examine whether, and to what extent, the availability of informal insurance provided by children mitigates the impact of health cost risk on pension demand. Table 3 reports the results.

[Table 3 here]

The $Health^{fair}$ and $Health^{good}$ coefficients are consistently positive and significant for pension participation and contribution decisions. In addition, the *Chronic_diseases* and *Health_risk* coefficients are consistently negative and significant. These results suggest that individuals with a low health cost risk and with no children are more likely to participate in pensions and contribute more to pensions after enrollment. In other words, health cost risk has a consistently negative impact on pension demand after teasing out the substitution effect of informal insurance on pensions.

Columns (1) and (4) of Table 3 show that the coefficients of the interaction terms between *Number_of_children* and $Health^{fair}$ or $Health^{good}$ are all negative and significant. The coefficients of the interaction terms between the *Number_of_children* and *Chronic_diseases* or *Health_risk* are all positive and significant, as shown in Columns (2), (3), (5), and (6). When compared with individuals in poor health, having one more child decreases the probability of participating in the RBP for individuals in fair (good) health by 2.45 (2.95) percentage points. When compared with pension participants in poor health, having one more child decreases the contributions of RBP participants in fair (good) health by 4.36% (4.34%). Having one more child on average mitigates the negative impact of *Chronic_diseases* on the probability of individuals participating in the RBP by 0.66 percentage points and mitigates the negative impact by 1.41% for the contributions of the RBP participants. Having one more child on average mitigates the negative impact of *Health_risk* on the probability of individuals participating in the RBP by 0.056 percentage points and mitigates the negative impact by 0.11% for the contributions of the RBP participants. These results suggest that the informal insurance provided by children mitigates the negative impact of health cost risk on pension demand. Compared with individuals with higher health cost risk, individuals with lower health cost risk are more likely to participate in pensions and contribute more after enrollment when they have little or no informal insurance, and they are less likely to participate and contribute less when they have sufficient informal insurance to substitute for a pension.

To be more specific, in terms of the pension participation decision, having two or more children can offset the positive impact of fair or good health on pension demand. Regarding the pension contribution decision, having four or more children offsets the positive impact of fair or good health on pension demand. The average number of children in our sample is 2.24. Therefore, the substitution effect of child-provided informal insurance on pensions drives the impact of having fair or good health on pension participation negative (Column (1), Table 2), while its impact on pension contribution remains positive (Columns (4), Table 2).

To illustrate the results in Table 3, Figure 1 presents the impact of having one more child on the individuals' pension demand under the poor, fair, and good health statuses, respectively. The better the health status (i.e., the lower the health cost risk), the greater the substitution effect of having one additional child on pensions. It is intuitive that individuals in poorer health need more physical, psychological, and financial support, and thus, need the support of more children to mitigate the reduction in pension demand. We emphasize that the role that informal insurance plays in the impact of health cost risk on annuitization decisions should be considered in the precautionary savings theory, and it must not be overlooked in theoretical and empirical investigations.

[Figure 1 here]

In a robustness test, we use *Rely_on_children* as an alternative measure of the existence of informal insurance. The results are consistent with our main results using *Number_of_children* and suggest that individuals in better health and who think they can rely on their children for help in their old-age are less likely to participate in and contribute less to a pension (see Section 6.2).

The results in Table 3 explain and reconcile the opposite impacts of the health cost risk on pension participation and contributions shown in Table 2. After a long history of lacking access to formal insurance, the RBP was introduced in areas where informal risk sharing arrangements (e.g., child-provided informal insurance) are prevalent. Relying on children for old-age support squeezes out the demand for formal insurance (Bloch, Genicot and Ray, 2008). Having more children can further mitigate the longevity risk and support the elderly life (Oliveira, 2016), and thus reduce the pension demand, especially for the individuals that are healthier and are therefore less of a responsibility to their children. Our results are consistent with the substitution effect of private family transfers on pension demand (Cai, Giles and Meng, 2006). We enrich the existing evidence by illustrating that the substitution effect of having children differs for parents with different health statuses.

4.3 Endogeneity

We address the potential endogeneity concern on *Health_cost_risk* measures in two ways. First, receiving pension benefits may improve an individual's health conditions through better nutrition and access to better healthcare (Jensen and Richter, 2004; Cheng et. al., 2018). This reverse causality concern can be excluded in our sample of 45–59 year olds because individuals were not receiving pension benefits until age 60. Second, wealth/income can simultaneously improve an individual's health conditions (Ettner, 1996; Cheng et. al., 2018) and increase the pension demand. In our main regressions, specifically, Eqs. (1) and (2), we control for the households' wealth per capita to capture individuals' financial conditions; we do not include income and wealth simultaneously because both are believed to capture similar financial conditions and including both may raise the concern of multicollinearity. Because income can represent a recent, stable flow of financial resources, we add individuals' *Ln(Net_income)* in addition to the households' wealth per capita to address the concern on the omitted variable of income. The results in Appendix A are consistent with our conclusions.

We also address the potential endogeneity concern of the *Informal_insurance* measure (i.e., *Number_of_children*) in two ways. First, individuals may expect a public pension and thus choose not to have more children. This reverse casualty concern can be excluded because individuals in our sample are 45–59 years old and made their fertility decisions 15-40 years ago when the RBP scheme did not exist and when they had neither access to nor expectation of any public pensions. Second, in the labor economics literature (e.g., Rosenzweig and Wolpin, 1980; Agüero and Marks, 2008), individuals' fertility preferences are considered to be a common omitted variable that causes an endogeneity problem. In our setup, however, omitting the fertility preference will not cause endogeneity in *Number_of_children* because fertility preference influences individuals' *Pension_demand* (i.e., the dependent variable) only through its impact on the *Number_of_children* (i.e., the explanatory variable of interest). The goal of this paper is exactly to investigate whether and how having and raising (more) children would affect individuals' annuitization decisions provided that children function as an informal insurance for old-age security. Therefore, the potential impact of the fertility preference has already been captured by the *Number_of_children.*

5. Additional analyses on the informal insurance effect

In this section, we conduct additional tests concerning the informal insurance's substitution effect on pensions in relation to children characteristics, parental (i.e., the annuitization decision maker's) characteristics, and regional characteristics.

5.1 Children characteristics: Education and gender differences

Education is a good measure for the ability of a child to support his or her elderly parents as it is a way to acquire human capital (Cervellati and Sunde, 2005) and a kind of parental human capital investment (Raut and Tran, 2005). In our sample, the respondents are 45 to 59 years old. Their children are still at school/university or have entered the workforce but are in an early stage of their careers, when education plays a greater role than in later career stages. Thus, education offers a reliable indication of the quality of child-provided informal insurance. Therefore, we examine whether better educated children mitigate more health cost risk impacts on the pension demand of their parents. Table 4 presents the results.

[Table 4 here]

As shown in Table 4, regardless of which health cost risk measures we use, the coefficients of the interaction terms are larger among the well-educated group. Among the less-educated group, when compared with individuals in poor health, having one more child decreases the probability of participating in the RBP for individuals in fair (good) health by 1.95 (2.06) percentage points (see Panel A, Column (1)). Among the well-educated group, these two numbers are 2.67 and 4.35 percentage points, respectively (see Panel A, Column (2)). Among the less-educated group, having one more child does not have a significantly different impact on the pension contributions of participants in poor, fair, or good health (see Panel A, Column (3)). Among the well-educated group, when compared with participants in poor health, having one more child decreases the contributions of pension participants in fair (good) health by 10.8% (12.3%) (see Panel A, Column (4)). Similar results are shown in Panels B and C, which further confirm the results that the substitution effect of better-educated children on pensions mitigates more of the health cost risk impact.

The gender of the children may be another factor influencing the old-age security they provide, although there is no consensus on the existence of gender differences (see e.g., Xie and Zhu, 2009; Oliveira, 2016; Chew et al., 2018). Traditionally, it is believed that sons, especially the eldest son, should take on the responsibility of the old-age support of their elderly parents. With continuous demographic, cultural, and economic changes, daughters are gradually taking on more responsibility than before and providing more financial support to their elderly parents (Xie and Zhu, 2009). To examine whether, and to what extent, sons and daughters mitigate the impact of the health cost risk on pension demand, we divide the *Number_of_children* into the *Number_of_sons* and the *Number_of_daughters*.

Table 5 presents the results of parents' having different-gender children. Both sons and daughters can mitigate the impact of the health cost risk on pension demand. The coefficients of the interaction terms between the health cost risk measures and the *Number_of_sons* as well as that between the health cost risk measures and the *Number_of_daughters* are not significantly different from each other, in most specifications. Our results show that the old-age support provided by children no longer depends on gender (Oliveira, 2016). Sons and daughters are the same now, at least from the perspective of old-age support.

[Table 5 here]

5.2 Parental characteristics: Income level and social networks

Children provide more support for parents who have lower incomes, given their altruistic motives (Cai, Giles and Meng, 2006). Thus, we compare how the health cost risk impact on pension demand is mitigated by informal insurance for parents with high versus low incomes. Table 6 reports the results. As Panel A shows, all coefficients of the interaction terms in Columns (2) and (4) are smaller than those in Columns (1) and (3). Similar results are shown in Panels B and C. The results in Table 6 confirm that the substitution effect of having children on pensions is more pronounced and can mitigate more health cost risk impacts for parents at lower income levels. These results are consistent with that the incidence and the amount of transfers from children to parents are negatively correlated with parents' income level (Cai, Giles and Meng, 2006).

[Table 6 here]

When people have more cohesive social networks, individuals can more easily form their own informal risk-sharing arrangements, which may further reduce their willingness to rely on the public pension system. Therefore, we estimate Eq. (2) for two subsamples, individuals with and without informal social networks, and report the results in Table 7. For those having at least one informal social network, when compared with individuals in poor health, having one more child decreases the probability of participating in the RBP program for individuals in fair (good) health by 3.35 (4.50) percentage points (see Panel A, Column (2)). Having one more child on average mitigates the negative impact of *Chronic_diseases* on the probability of individuals participating in the RBP by 0.89 percentage points (see Panel B, Column (2)). Having one more child on average mitigates the negative impact of *Health_risk* on the probability of individuals participating in the RBP by 0.080 percentage points (see Panel C, Column (2)).

[Table 7 here]

In Column (1) of Table 7, all coefficients of *Number_of_children* and the interaction terms between *Number_of_children* and the various health cost risk measures are insignificant. This indicates that, for individuals without informal social networks, their children neither play a role in substituting for the pension nor mitigate the impact of the health cost risk on their parents' annuitization decisions. This is probably because the parents who do not facilitate their own informal risk-sharing arrangements may also not be (financially) close with their children. Thus, they rely on the formal public pension system. Regarding the pension contribution, the results in Columns (3) and (4) also indicate that the health cost risk impact is mitigated more for individuals with informal social networks.

5.3 Regional characteristics: Male–female ratio, mobility, and development level

A preference for sons is widespread in many developing countries (Chew et al., 2018). Raising sons for old-age support is prevalent and rooted in the Confucian-Chinese culture (Zhou, 2014), especially in less developed areas. Hence, the male–female ratio in a region can be distorted by its culture preference for sons. China's one-child policy further increases the number of males in the country, as some households with a son preference would terminate a pregnancy if the fetus was identified as female to ensure their only child is male (Jayachandran, 2017).

It is expected that the preference for sons is higher in regions with a higher male–female ratio.

Therefore, we divide the sample into regions with a high male–female ratio and regions with a low male–female ratio based on the median ratio of all provinces in China's mainland. We estimate Eq. (2) in these two subsamples. Table 8 reports the results and indicates that the substitution effect of having children on pensions mitigates more of the health cost risk impact in areas with high male–female ratios. A high male–female ratio reflects a higher level of gender selection prior to birth and a more powerful ideology about bringing up sons to support parents in their old age.

[Table 8 here]

High regional mobility correlates with the problem of pension account migration and the continuation of a pension scheme when moving between provinces, which increases the complexity of pension participation and induces transaction costs. Thus, high regional mobility may decrease individuals' pension demand. In addition, high mobility correlates with the living arrangement within a household. Given the altruism motive, migrant adults who work outside their home villages or communities and do not live close to their parents may provide more financial transfers as compensation for providing less physical and emotional support. Receiving money from children serves as a substitute for parents' pension. Both implications suggest that high regional mobility reduces the demand for public pensions. We thus estimate Eq. (2) in the subsamples with high and low regional mobility. The threshold is 10% of the registered residents work outside of the village or community for more than three months, which is around the one-third quantile of our sample. Table 9 reports the results. Regardless of which health cost risk measures we use, the coefficients of the interaction terms of informal insurance and health cost risk only remain significant for those in high-mobility regions, indicating that the health cost risk impact is mitigated more significantly in regions with high mobility.

[Table 9 here]

In less-developed areas in China, informal social and economic ties are important in household financial decisions (Bu and Liao, 2022). The results in Table 10 show that the interaction terms between *Number_of_children* and the health cost risk measures are only significant in the middle and western provinces. These results are consistent with informal insurance being more widely used in underdeveloped areas (Bloch, Genicot and Ray, 2008). The basic pension benefits of the RBP in the middle and western provinces are much lower than in the eastern provinces due to differences in economic development, and the pension benefits are insufficient to financially support people in their old age. Thus, informal insurance (from children or other social networks) is the main source to mitigate longevity risks. Using an alternative measure for development levels, we estimate Eq. (2) in two subsamples: urban and rural areas. As expected, the substitution effect of informal insurance on pensions mitigates the health cost risk impact more pronounced in rural (i.e., less-developed) areas than in urban areas (see Section 6.2).

[Table 10 here]

6. Robustness

6.1 Alternative explanations

In this section, we discuss explanations other than child-provided informal insurance to explain the seemingly opposite health cost risk impact on pension participation and contributions. These explanations could include income and property ownership.

First, higher net income or net labor income of an individual captures greater competence in the labor market. Since good health increases workers' labor force attachment (Disney, Emmerson and Wakefield, 2006), it is intuitive that individuals in better health and with higher net total/labor income work longer and are able to better support themselves in their old age, and therefore, have lower demand for pensions. The work-until-not-possible rationale is particularly prominent in rural China, where farmers are not used to stopping work or retiring at a certain age (Giles, Wang and Zhao, 2010).

Second, rental income and the ownership of houses/apartments or farming land also capture a potential income stream. The income stream from properties also provides a potential substitute for pension income. Farming land is an important and conventional income source that supports farmers' old age in China, which generates income streams, either by land transfers or self-employment. Similarly, individuals who own houses or apartments can rent them out or mortgage them to generate income streams.

Given the above rationales, we analyze the moderating effects of net income, net labor income, rental income, and property ownership to determine whether they explain our seemingly opposite health cost impact on pension participation and contributions. The results presented in Tables 11 and 12 show that almost all the interaction terms between the health cost risk and *Ln(Net_income)*, *Ln(Labor_income)*, *Ln(Rental_income)*, and *Property_ownership* are insignificant, indicating that net income, net labor income, rental income, and property ownership can not explain the opposite results in Table 2.

[Table 11 here]

[Table 12 here]

In addition, we examine the differences between the pension participants and nonparticipants in these four aspects, given the individual's health status. The *t*-test results in Appendix B1 also show that the average *Net_income*, *Labor_income,* and *Rental_income* are not significantly different between the RBP participants and nonparticipants. The rate of house/apartment or land ownership is higher among RBP participants than nonparticipants, which is contrary to the idea that properties can substitute for pensions. The results exclude income and property ownership as alternative explanations for our findings.

The informal insurance function of children cannot be replaced by an individual's labor or property income for three reasons. First, financial exchange or old-age security is an important motive for fertility (Rossi and Godard, 2022), especially when the formal pension system is immature, insufficient, and/or difficult to access. Second, children are considered to be a more reliable source of continuous income than an individual's labor, due to age and health differences as well as than property income, as the property market may be illiquid and underdeveloped, especially in rural and other noncity areas. Third, children can provide meaningful physical and psychological support (Kotlikoff and Spivak, 1981; Foster and Rosenzweig, 2001), in addition to financial income to parents. This is particularly true for the healthier elderly, as they are less of a burden to their children.

6.2 Other robustness tests

We conduct additional tests using alternative samples/measures or considering additional control variables to verify the robustness of our results. First, we use a full sample including both pension participants and nonparticipants to estimate the impact of health cost risk on pension contributions, in which nonparticipants have zero contributions. Estimating Eq. (1), the coefficients of the health cost risk become smaller or insignificant, suggesting that the positive effect on pension participation (i.e., the extensive margin) and the negative impact on pension contribution (i.e., the intensive margin) offset each other. Estimating Eq. (2)—where the impact of informal insurance is teased out—the impact of health cost risk on pension contributions is consistently negative as the mainstream theory predicts (see Appendix B2).

Second, we use *Rely_on_children* as an alternative to measure the existence of informal insurance, which captures an individual's subjective beliefs about relying on their children for old-age support. Regardless of which health cost risk measure we use, the coefficients of the interaction terms between *Rely_on_children* and *Health_cost_risk* are found to be significant and consistent with our primary results in Table 3. The results suggest that individuals in better health and those who think they can rely on their children for their old-age are less likely to participate in and contribute to pensions (see Appendix B3 and Figure B1).

Third, we consider that the substitution effect of having children on pensions might not be linear; for example, it might marginally decrease for each additional child as elder children are commonly thought to be more capable and thus take more responsibility for their parents than younger children. We use Ln(*Number_of_children*) to capture the marginal decreasing substitution effect of having more children. The results are consistent with our primary results using *Number_of_children* as the informal insurance measure in Table 3 (see Appendix B4).

Fourth, we use individuals' registered residence as an alternative measure for the regional development level in the heterogeneity analysis. We estimate Eq. (2) in two subsamples: urban and rural areas. As expected, the substitution effect of informal insurance on pensions mitigates the health cost risk impact more pronounced in rural (i.e., less-developed) areas (see Appendix B5).

Fifth, an individual's pension participation decision might also be motivated by the bundling policy of parents and children. That is, people aged 60 or older at the time of the RBP introduction can receive pension benefits without any contribution if their eligible children participate in a public pension program. We therefore additionally control a dummy variable, *Living_parent*, indicating whether the respondent has at least one living parent. The results are consistent with our primary results in Table 2 and Table 3 (see Appendix B6). Moreover, we estimate Eqs. (1) and (2) using clustered standard errors at the household level. The findings are robust (see Appendix B7).

Sixth, age is an important determinant of an individual's health, health cost risk, and thus pension decisions. Therefore, the impact of health cost risk on pension demand may change as age increases. We add an interaction term between health cost risk and age dummies. The results show that the interaction terms are all insignificant, suggesting that age does not change the relationship between health cost risk and pension demand (see Appendix B8).

7. Conclusion

The theory of health cost risk explains a large part of the empirically observed annuity puzzle (Peijnenburg, Nijman and Werker, 2017). On the one hand, health cost risk motivates liquidity needs, and thus decreases annuity demand (Davidoff, Brown and Diamond, 2005; Turra and Mitchell, 2008; Peijnenburg, Nijman and Werker, 2017). On the other hand, health cost risk may drive household portfolios to shift from risky equities to safer annuities (Pang and Warshawsky, 2010). This paper provides the first piece of empirical evidence regarding the impact of health cost risk on annuitization decisions and pension demand.

We document a seemingly contradictory result: the health cost risk increases the probability of pension participation but decreases the amount of pension contributions. We show that this contradictory result is driven by the effect of child-provided informal insurance. Teasing out the effect of informal insurance, individuals with lower health cost risk and with no children are more likely to participate in a pension and contribute more after enrollment. In terms of the pension participation decision, having two or more children can offset the positive impact of fair or good health on pension demand. Regarding the pension contribution decisions, having four or more children would offset the positive impact of fair or good health on pension demand. We rule out income and property ownership as explanations for the seemingly opposite impacts of health cost risk on pension participation and contributions.

The substitution effect of informal insurance on pensions mitigates the health cost risk impact more pronounced for households that have better-educated children, lower incomes, and more informal social networks and those in regions that have a higher male–female ratio, that have higher mobility, or are less developed. However, we observe no gender differences for children who provide informal insurance for their parents. Our finding regarding gender equality is consistent with a recent study showing that male and female children no longer display any significant differences in providing old-age support in China (Oliveira, 2016).

Our results explain the seemingly contradictory result of the health cost risk impact on pension participation and pension contributions. After teasing out the impact of child-provided informal insurance, our results are consistent with the mainstream theoretical prediction that health cost risk reduces pension demand (Davidoff, Brown and Diamond, 2005; Turra and Mitchell, 2008; Peijnenburg, Nijman and Werker, 2017). To derive this result, it is important to disentangle the health cost risk from the longevity risk and to fully account for the substitution effect of child-provided informal insurance on pensions. These theoretical predictions are empirically observable and verifiable only when fully taking into account the heterogeneous substitution effect of informal insurance on pensions among individuals with different health cost risks.

In practice, informal insurance within a household, or within other social networks, is prevalent when the individual has limited access to the formal insurance system (Bu and Liao, 2022). People are, as empirically observed in this paper, more likely to rely on their existing informal insurance when the old-age support motive remains an important reason for fertility and when public pensions are insufficient. Our results highlight the importance of taking a holistic view on household financial decisions.

Figures and Tables

Figure 1 Substitution effect of informal insurance on pensions in respective health status

Figure 1 presents the impact of having one more child on individuals' pension demand under the poor, fair, and good health statuses (i.e., the average marginal effects of *Number_of_children* at different health statuses after regression reported in Columns (1) and (4), Table 3). *Pension_participation* is the dependent variable in Column (1) of Table 3, which is a dummy variable that equals 1 when individuals participated in the RBP program. *Ln(Pension_contribution)* is the dependent variable in Column (4) of Table 3, which is a log form continuous variable representing the annual contributions that individuals paid to the RBP program. $Health^{poor}$ equals 1 when the self-reported health status is very poor or poor, and 0 otherwise. $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. *Number_of_children* is the number of the individual's living children. As shown in Figure 1, the better the health status (i.e., the lower the health cost risk), the greater the substitution effect of having one additional child on pensions.

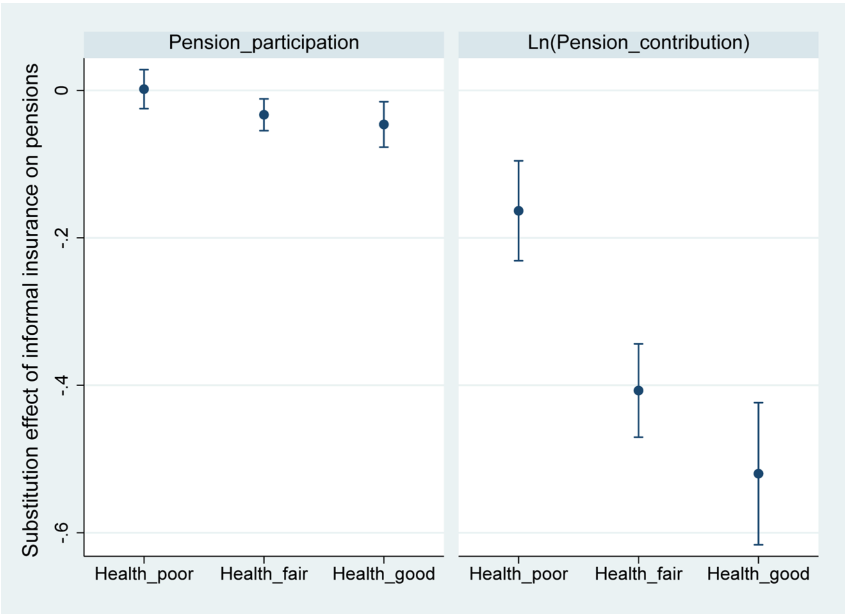

Table 1 Summary statistics

This table presents the summary statistics of our sample. Panel A presents the summary statistics of the key variables. *Pension_participation* is a dummy variable that equals 1 when individuals participated in the RBP program. *Pension_contribution* is a continuous variable representing the annual contributions that individuals paid to the RBP program. $Health^{poor}$, $Health^{fair}$ and $Health^{good}$ are three dummy variables of self-reported health statuses. *Chronic_diseases* is the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Unlikely_75*, *Maybe_75* and *Likely_75* equal 1 when the individual evaluates his/her chances of reaching the age of 75 as "almost impossible or not very likely," "maybe," and "very likely or almost certain," respectively. *Number_of_children* is the number of the individual's living children. *Rely_on_children* equals 1 when the individual expects children to be his/her main financial resource in old-age, and 0 when the individual expects savings, public or private pensions, or other financial resources as the main financial resource for old age.

Panel B presents the summary statistics of the control variables. *Age is* the individual's age. *Male* equals 1 when the individual is male. *Minority* equals 1 when the individual is in a minority ethnic group and 0 when the individual is in the majority ethnic group (*Han*). *Married* equals 1 when the individual is married. $Education^{illiterate}$, $Education^{elementary}$ and $Education^{middleabove}$ are three dummy variables of individuals' education levels. *Physical_exam* equals 1 when the individual has taken a physical examination within the past two years. *Health_insurance* equals 1 when the individual has public health insurance. *Wealth* is the household wealth per capita. *Urban* equals 1 when the individual's registered residence (*hukou*) is urban. $Life^{unsatisfied}$, $Life^{somewhat\_satisfied}$ and $Life^{satisfied}$ equal 1 when the individual feels "not at all satisfied or not very satisfied," "somewhat satisfied," and "very satisfied or completely satisfied" with his/her life, respectively.

Panel C presents the summary statistics of the additional variables used in the heterogeneity analyses and robustness tests. $Education_{children}^{advanced}$ equals 1 when the individual's children have an advanced education. *Number_of_sons* and *Number_of_daughters* are the number of the individual's living sons and living daughters, respectively. $Income^{high}$ equals 1 when the individual's income is equal to or above the median income level in the sample. *Informal_social_networks* equals 1 when the individual has at least one informal social network. $Male\_female\_ratio^{high}$ equals 1 when the region's male–female ratio is equal to or greater than the median male–female ratio for all provinces in China's mainland. $Regional\ mobility^{high}$ equals 1 when the proportion of registered residents working outside the village or community for more than three months is equal to or greater than 10%. *Eastern_provinces* equals 1 when the individual's registered residence is among the 11 eastern provinces in China. *Labor_income* is the sum of the individual's wage income, individual-based transfers, net agricultural income per capita, net livestock income per capita, and net income from self-employed activities per capita, noting that it could be negative. *Rental_income* is income from a house/apartment and/or land rent per capita. *Net_income* includes *Labor_income*, *Rental_income*, and household public transfer income per capita. *Property_ownership* equals 1 when the individual owns land or a house/apartment. *Living_parent* equals 1 when the respondent has at least one living parent.

	Obs.	Mean	S.D.	Min	Median	Max
Panel A Key variables						
Pension_participation	14,324	0.79	0.40	0	1	1
Pension_contribution (CNY, incl. zero)	13,734	254.1	768.0	0	100	9,000
Pension_contribution (CNY, excl. zero)	10,789	323.5	853.4	100	100	9,000
$Health^{poor}$	14,322	0.24	0.43	0	0	1
$Health^{fair}$	14,322	0.50	0.50	0	1	1
$Health^{good}$	14,322	0.26	0.44	0	0	1
Chronic_diseases	14,323	1.47	1.54	0	1	12
Health_risk	14,319	0.25	0.17	0.054	0.18	0.63
Unlikely_75	14,324	0.29	0.46	0	0	1
Maybe_75	14,324	0.39	0.49	0	0	1
Likely_75	14,324	0.32	0.47	0	0	1
Number_of_children	14,324	2.24	1.01	0	2	10
Rely_on_children	13,894	0.73	0.45	0	1	1
Panel B Control variables						
Age	14,324	52.5	3.97	45	52	59
Male	14,324	0.47	0.50	0	0	1
Minority	14,324	0.11	0.31	0	0	1
Married	14,324	0.95	0.22	0	1	1
$Education^{illiterate}$	14,324	0.16	0.37	0	0	1
$Education^{elementary}$	14,324	0.43	0.49	0	0	1
$Education^{middleabove}$	14,324	0.41	0.49	0	0	1
Physical_exam	14,324	0.35	0.48	0	0	1
Health_insurance	14,324	0.96	0.20	0	1	1
Wealth_per_capita (CNY 10000)	14,324	12.7	34.6	0.0050	4.59	500.5
Urban	14,324	0.070	0.26	0	0	1
$Life^{unsatisfied}$	14,324	0.14	0.35	0	0	1
$Life^{somewhat\_satisfied}$	14,324	0.56	0.50	0	1	1
$Life^{satisfied}$	14,324	0.30	0.46	0	0	1
Panel C Additional variables						
$Education_{children}^{advanced}$	14,123	0.31	0.46	0	0	1
Number_of_sons	14,324	1.18	0.79	0	1	8
Number_of_daughters	14,324	1.07	0.92	0	1	7
$Income^{high}$	14,321	0.50	0.50	0	1	1
Informal_social_networks	14,323	0.58	0.49	0	1	1
$Male\_female\_ratio^{high}$	14,324	0.45	0.50	0	0	1
$Regional\_mobility^{high}$	12,384	0.67	0.47	0	1	1
Eastern_provinces	14,324	0.32	0.47	0	0	1
Net_income	14,321	9,191.4	19,516.7	-50,000	1,666.7	250,300
Labor_income	14,321	8,203.4	17,431.1	-46,300	675	210,000
Rental_income	14,045	237.6	1,470.0	0	0	30,000
Property_ownership	14,291	0.98	0.15	0	1	1
Living_parent	14,314	0.68	0.47	0	1	1

Table 2 Impact of health cost risk on annuitization decisions

This table presents the estimation for Eq. (1): the impact of health cost risk on pension demand. Columns (1)–(3) use the full sample to estimate the impact on pension participation and report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) use the sample of pension participants to estimate the impact on pension contributions and report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children, measuring child-provided informal insurance of the individual. The control variables include *Maybe_75*, *Likely_75*, *Age*, *Male*, *Minority*, *Married*, $Education^{elementary}$, $Education^{middleabove}$, *Physical_exam*, *Health_insurance*, *Ln(Wealth)*, *Urban*, $Life^{somewhat\_satisfied}$, and $Life^{satisfiedhave}$, which have been defined in Table 1. Robust standard errors are provided in parentheses. *, **, *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Health^{fair}$	-0.0170**			0.0287*		
	(0.00802)			(0.0174)		
$Health^{good}$	-0.0200**			0.105***		
	(0.00998)			(0.0229)		
Chronic_diseases		0.00491**			-0.00935*	
		(0.00220)			(0.00483)	
Health_risk			0.0484**			-0.126***
			(0.0204)			(0.0449)
Maybe_75	0.0220***	0.0209***	0.0220***	0.0346**	0.0440***	0.0390**
	(0.00761)	(0.00755)	(0.00760)	(0.0169)	(0.0167)	(0.0168)
Likely_75	0.0261***	0.0244***	0.0258***	0.0679***	0.0868***	0.0801***
	(0.00820)	(0.00803)	(0.00811)	(0.0194)	(0.0191)	(0.0195)
Number_of_children	0.00186	0.00160	0.00185	-0.0766***	-0.0773***	-0.0773***
	(0.00326)	(0.00327)	(0.00325)	(0.00780)	(0.00780)	(0.00781)
Age	0.00651***	0.00641***	0.00627***	0.00325*	0.00315*	0.00374**
	(0.000774)	(0.000776)	(0.000791)	(0.00185)	(0.00186)	(0.00190)
Male	-0.0267***	-0.0269***	-0.0259***	-0.0370**	-0.0335**	-0.0365**
	(0.00645)	(0.00644)	(0.00646)	(0.0157)	(0.0157)	(0.0157)
Minority	0.0118	0.0118	0.0116	-0.0415*	-0.0405*	-0.0416*
	(0.0106)	(0.0106)	(0.0106)	(0.0235)	(0.0236)	(0.0236)
Married	0.0538***	0.0535***	0.0539***	0.0619*	0.0597*	0.0587*
	(0.0151)	(0.0151)	(0.0151)	(0.0349)	(0.0351)	(0.0350)
$Education^{elementary}$	0.00701	0.00652	0.00718	0.0696***	0.0682***	0.0664***
	(0.00922)	(0.00921)	(0.00921)	(0.0189)	(0.0190)	(0.0190)
$Education^{middleabove}$	0.0232**	0.0223**	0.0234**	0.129***	0.131***	0.128***
	(0.00975)	(0.00975)	(0.00975)	(0.0215)	(0.0215)	(0.0215)
Physical_exam	0.00263	0.00148	0.00271	0.0886***	0.0898***	0.0875***
	(0.00648)	(0.00655)	(0.00648)	(0.0164)	(0.0165)	(0.0164)
Health_insurance	0.300***	0.298***	0.300***	-0.0830	-0.0846	-0.0872
	(0.0205)	(0.0205)	(0.0205)	(0.0600)	(0.0604)	(0.0603)
Ln(Wealth)	0.00907***	0.00889***	0.00916***	0.0271***	0.0284***	0.0275***
	(0.00195)	(0.00194)	(0.00196)	(0.00487)	(0.00486)	(0.00488)
Urban	-0.242***	-0.243***	-0.242***	0.918***	0.921***	0.920***
	(0.0157)	(0.0157)	(0.0157)	(0.0764)	(0.0765)	(0.0765)
$Life^{somewhat\_satisfied}$	0.0202**	0.0184**	0.0205**	-0.0506**	-0.0422**	-0.0477**
	(0.00898)	(0.00889)	(0.00897)	(0.0213)	(0.0210)	(0.0214)
$Life^{satisfied}$	0.0186*	0.0166*	0.0186*	-0.0352	-0.0161	-0.0226
	(0.00996)	(0.00980)	(0.00988)	(0.0243)	(0.0238)	(0.0242)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,322	14,323	14,319	10,788	10,788	10,787
(Pseudo) R^2	0.185	0.185	0.185	0.215	0.214	0.214

Table 3 Substitution effect of informal insurance on pensions

This table presents the estimation for Eq. (2): whether, and to what extent, the availability of informal insurance provided by children mitigates the impact of health cost risk on pension demand. Columns (1)–(3) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Health^{fair}$	0.0397**			0.132***		
	(0.0193)			(0.0456)		
$Health^{good}$	0.0428**			0.208***		
	(0.0207)			(0.0560)		
Chronic_diseases		-0.0103**			-0.0430***	
		(0.00489)			(0.0126)	
Health_risk			-0.0814*			-0.382***
			(0.0463)			(0.111)
$Health^{fair}$ × Number_of_children	-0.0245***			-0.0436***		
	(0.00762)			(0.0167)		
$Health^{good}$ × Number_of_children	-0.0295***			-0.0434**		
	(0.00945)			(0.0202)		
Chronic_diseases × Number_of_children		0.00658***			0.0141***	
		(0.00191)			(0.00480)	
Health_risk × Number_of_children			0.0562***			0.108***
			(0.0180)			(0.0400)
Number_of_children	0.0201***	-0.00857*	-0.0138**	-0.0454***	-0.101***	-0.107***
	(0.00635)	(0.00439)	(0.00588)	(0.0128)	(0.0114)	(0.0143)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,322	14,323	14,319	10,788	10,788	10,787
(Pseudo) R^2	0.186	0.186	0.186	0.216	0.214	0.214

Table 4 Heterogeneous impact of informal insurance (children's education)

This table presents the estimation for Eq. (2) in two subsamples: having children with advanced educations versus having children without advanced educations. The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. $Education^{advanced}_{children}$ equals 1 when the individual's children have an advanced education (i.e., two or three years of college or an associate's degree or higher levels of schooling), and 0 otherwise. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	$Education^{advanced}_{children}$ = 0	$Education^{advanced}_{children}$ = 1	$Education^{advanced}_{children}$ = 0	$Education^{advanced}_{children}$ = 1
	(1)	(2)	(3)	(4)
Panel A Health status				
$Health^{fair}$	0.0212	0.0525	0.0683	0.284***
	(0.0239)	(0.0373)	(0.0508)	(0.104)
$Health^{good}$	0.0294	0.0523	0.122*	0.394***
	(0.0270)	(0.0365)	(0.0640)	(0.120)
$Health^{fair}$ × Number_of_children	-0.0195**	-0.0267*	-0.0170	-0.108***
	(0.00943)	(0.0141)	(0.0183)	(0.0377)
$Health^{good}$ × Number_of_children	-0.0206*	-0.0435**	-0.00650	-0.123***
	(0.0120)	(0.0169)	(0.0233)	(0.0426)
Number_of_children	0.0133*	0.0282**	-0.0556***	-0.0289
	(0.00772)	(0.0116)	(0.0138)	(0.0306)
Observations	9,791	4,325	7,345	3,323
(Pseudo) R^2	0.184	0.199	0.205	0.253
Panel B Chronic disease				
Chronic_diseases	-0.00915	-0.0114	-0.00484	-0.116***
	(0.00602)	(0.00979)	(0.0135)	(0.0228)
Chronic_diseases × Number_of_children	0.00566**	0.00840**	-0.000797	0.0424***
	(0.00234)	(0.00386)	(0.00488)	(0.00783)
Number_of_children	-0.00949*	-0.00851	-0.0649***	-0.185***
	(0.00564)	(0.00793)	(0.0131)	(0.0217)
Observations	9,792	4,325	7,345	3,323
(Pseudo) R^2	0.183	0.198	0.203	0.255
Panel C Health risk				
Health_risk	-0.0491	-0.0738	-0.208*	-0.803***
	(0.0576)	(0.0856)	(0.124)	(0.247)
Health_risk × Number_of_children	0.0469**	0.0538*	0.0297	0.299***
	(0.0225)	(0.0319)	(0.0440)	(0.0897)
Number_of_children	-0.0138*	-0.0101	-0.0744***	-0.193***
	(0.00757)	(0.0102)	(0.0166)	(0.0288)
Observations	9,788	4,325	7,344	3,323
(Pseudo) R^2	0.184	0.197	0.203	0.252
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 5 Heterogeneous impact of informal insurance (children's genders)

This table presents the estimation for Eq. (2): whether, and to what extent, sons and daughters mitigate the impact of the health cost risk on pension demand. Columns (1)–(3) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_sons* and *Number_of_daughters* are the number of the individual's living sons and living daughters, respectively. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Health^{fair}$	0.0368*			0.137***		
	(0.0195)			(0.0474)		
$Health^{good}$	0.0406*			0.221***		
	(0.0209)			(0.0578)		
Chronic_diseases		-0.0105**			-0.0469***	
		(0.00490)			(0.0128)	
Health_risk			-0.0755			-0.405***
			(0.0466)			(0.115)
$Health^{fair}$ × Number_of_sons	-0.0180*			-0.0511**		
	(0.0100)			(0.0238)		
$Health^{good}$ × Number_of_sons	-0.0240*			-0.0672**		
	(0.0123)			(0.0286)		
$Health^{fair}$ × Number_of_daughters	-0.0293***			-0.0395**		
	(0.00884)			(0.0175)		
$Health^{good}$ × Number_of_daughters	-0.0336***			-0.0297		
	(0.0111)			(0.0223)		
Chronic_diseases × Number_of_sons		0.00712***			0.0214***	
		(0.00257)			(0.00662)	
Chronic_diseases × Number_of_daughters		0.00629***			0.00952*	
		(0.00226)			(0.00494)	
Health_risk × Number_of_sons			0.0421*			0.146**
			(0.0237)			(0.0574)
Health_risk × Number_of_daughters			0.0669***			0.0873**
			(0.0211)			(0.0424)
Number_of_sons	0.0127	-0.0124**	-0.0128	-0.0478**	-0.126***	-0.129***
	(0.00808)	(0.00595)	(0.00778)	(0.0181)	(0.0167)	(0.0205)
Number_of_daughters	0.0253***	-0.00645	-0.0150**	-0.0446***	-0.0876***	-0.0956***
	(0.00740)	(0.00494)	(0.00673)	(0.0135)	(0.0117)	(0.0150)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,322	14,323	14,319	10,788	10,788	10,787
(Pseudo) R^2	0.186	0.186	0.186	0.216	0.215	0.215

Table 6 Heterogeneous impact of informal insurance (income level)

This table presents the estimation for Eq. (2) in two subsamples: high and low incomes of the pension decision makers. The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. $Income^{high}$ equals 1 when the individual's income is equal to or above the median income level in the sample, and 0 otherwise. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. *, **, *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	$Income^{high}$=0	$Income^{high}$=1	$Income^{high}$=0	$Income^{high}$=1
	(1)	(2)	(3)	(4)
Panel A Health status				
$Health^{fair}$	0.0337	0.0505	0.163***	0.0896
	(0.0236)	(0.0320)	(0.0593)	(0.0710)
$Health^{good}$	0.0660***	0.0260	0.251***	0.142*
	(0.0255)	(0.0337)	(0.0754)	(0.0828)
$Health^{fair}$ × Number_of_children	-0.0262***	-0.0226*	-0.0516**	-0.0341
	(0.00926)	(0.0127)	(0.0223)	(0.0252)
$Health^{good}$ × Number_of_children	-0.0424***	-0.0178	-0.0703**	-0.0150
	(0.0125)	(0.0146)	(0.0274)	(0.0295)
Number_of_children	0.0197***	0.0204*	-0.0357**	-0.0600***
	(0.00706)	(0.0114)	(0.0166)	(0.0199)
Observations	7,157	7,162	5,403	5,384
(Pseudo) R^2	0.195	0.187	0.208	0.231
Panel B Chronic disease				
Chronic_diseases	-0.0133**	-0.00790	-0.0576***	-0.0245
	(0.00626)	(0.00770)	(0.0175)	(0.0176)
Chronic_diseases × Number_of_children	0.00690***	0.00653**	0.0184***	0.00882
	(0.00238)	(0.00313)	(0.00686)	(0.00630)
Number_of_children	-0.0117**	-0.00595	-0.106***	-0.0957***
	(0.00584)	(0.00664)	(0.0149)	(0.0174)
Observations	7,158	7,162	5,404	5,383
(Pseudo) R^2	0.193	0.188	0.208	0.229
Panel C Health risk				
Health_risk	-0.102*	-0.0859	-0.408***	-0.317*
	(0.0569)	(0.0815)	(0.142)	(0.176)
Health_risk × Number_of_children	0.0727***	0.0451	0.123**	0.0860
	(0.0221)	(0.0321)	(0.0528)	(0.0614)
Number_of_children	-0.0234***	-0.00619	-0.113***	-0.102***
	(0.00837)	(0.00850)	(0.0200)	(0.0205)
Observations	7,157	7,162	5,403	5,384
(Pseudo) R^2	0.194	0.187	0.207	0.230
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 7 Heterogeneous impact of informal insurance (informal social networks)

This table presents the estimation for Eq. (2) in two subsamples: individuals with and without informal social networks. The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. *Informal_social_networks* equals 1 when the individual has one or more informal social networks, and 0 when the individual has none of the informal social network. Informal social networks are defined in CHALRS, include: (i) interacting with friends; (ii) playing ma-jong, playing chess, playing cards, or going to a community club; (iii) providing help to family, friends, or neighbors who do not live with you; (iv) going to a sport, social, or other kind of club; (v) taking part in a community-related organization; (vi) conducting voluntary or charity work; (vii) caring for a sick or disabled adult who does not live with you; (viii) attending an educational or training course; (ix) making a stock investment; (x) using the internet; and (xi) others. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	Informal_social_ networks=0	Informal_social_ networks =1	Informal_social_ networks =0	Informal_social_ networks =1
	(1)	(2)	(3)	(4)
Panel A Health status				
$Health^{fair}$	0.0234	0.0582**	0.0527	0.180***
	(0.0276)	(0.0266)	(0.0613)	(0.0660)
$Health^{good}$	0.0291	0.0618**	0.101	0.267***
	(0.0310)	(0.0273)	(0.0757)	(0.0794)
$Health^{fair}$ × Number_of_children	-0.0158	-0.0335***	-0.0190	-0.0590**
	(0.0112)	(0.0102)	(0.0218)	(0.0247)
$Health^{good}$ × Number_of_children	-0.0135	-0.0450***	-0.00296	-0.0661**
	(0.0137)	(0.0129)	(0.0262)	(0.0294)
Number_of_children	0.00829	0.0314***	-0.0298*	-0.0611***
	(0.00937)	(0.00836)	(0.0159)	(0.0198)
Observations	6,083	8,235	4,563	6,224
(Pseudo) R^2	0.194	0.186	0.201	0.238
Panel B Chronic disease				
Chronic_diseases	-0.000542	-0.0181***	-0.0365**	-0.0472***
	(0.00687)	(0.00668)	(0.0177)	(0.0170)
Chronic_diseases × Number_of_children	0.00336	0.00894***	0.0142**	0.0128**
	(0.00270)	(0.00259)	(0.00662)	(0.00645)
Number_of_children	-0.00809	-0.00900	-0.0636***	-0.128***
	(0.00645)	(0.00594)	(0.0153)	(0.0162)
Observations	6,082	8,237	4,562	6,225
(Pseudo) R^2	0.194	0.185	0.200	0.237
Panel C Health risk				
Health_risk	-0.0491	-0.125**	-0.102	-0.538***
	(0.0670)	(0.0630)	(0.148)	(0.161)
Health_risk × Number_of_children	0.0330	0.0804***	0.0170	0.156***
	(0.0269)	(0.0239)	(0.0510)	(0.0599)
Number_of_children	-0.0116	-0.0170**	-0.0449**	-0.148***
	(0.00869)	(0.00793)	(0.0193)	(0.0203)
Observations	6,083	8,232	4,563	6,223
(Pseudo) R^2	0.194	0.186	0.199	0.237
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 8 Heterogeneous impact of informal insurance (regional male–female ratio)

This table presents the estimation for Eq. (2) in two subsamples: high and low regional male–female ratio. The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. $Male\_female\_ratio^{high}$ equals 1 when the region's male–female ratio is equal to or greater than the median male–female ratio for all provinces in China's mainland, and 0 otherwise. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. *, **, *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	Male_female_ ratio^{high} =0	Male_female_ ratio^{high} =1	Male_female_ ratio^{high} =0	Male_female_ ratio^{high} =1
	(1)	(2)	(3)	(4)
Panel A Health status				
Health^{fair}	0.0261	0.0520*	0.140**	0.138**
	(0.0262)	(0.0272)	(0.0642)	(0.0647)
Health^{good}	0.0196	0.0666**	0.208***	0.222***
	(0.0290)	(0.0279)	(0.0746)	(0.0860)
Health^{fair} × Number_of_children	-0.0210*	-0.0257**	-0.0462*	-0.0440*
	(0.0109)	(0.0102)	(0.0245)	(0.0228)
Health^{good} × Number_of_children	-0.0134	-0.0433***	-0.0386	-0.0524*
	(0.0128)	(0.0134)	(0.0276)	(0.0303)
Number_of_children	0.0153*	0.0219***	-0.0520***	-0.0328**
	(0.00924)	(0.00815)	(0.0194)	(0.0167)
Observations	7,915	6,407	6,018	4,770
(Pseudo) R^2	0.188	0.224	0.233	0.202
Panel B Chronic disease				
Chronic_diseases	-0.00576	-0.0145**	-0.0354**	-0.0547***
	(0.00633)	(0.00728)	(0.0149)	(0.0203)
Chronic_diseases × Number_of_children	0.00500*	0.00796***	0.00950*	0.0205***
	(0.00257)	(0.00276)	(0.00546)	(0.00762)
Number_of_children	-0.00631	-0.0114*	-0.0996***	-0.101***
	(0.00605)	(0.00628)	(0.0156)	(0.0161)
Observations	7,914	6,409	6,017	4,771
(Pseudo) R^2	0.188	0.223	0.231	0.202
Panel C Health risk				
Health_risk	-0.0287	-0.136**	-0.372**	-0.431***
	(0.0632)	(0.0646)	(0.156)	(0.156)
Health_risk × Number_of_children	0.0359	0.0698***	0.0962	0.127**
	(0.0258)	(0.0240)	(0.0591)	(0.0543)
Number_of_children	-0.00771	-0.0190**	-0.110***	-0.102***
	(0.00808)	(0.00836)	(0.0199)	(0.0204)
Observations	7,914	6,405	6,018	4,769
(Pseudo) R^2	0.187	0.223	0.232	0.201
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 9 Heterogeneous impact of informal insurance (regional mobility)

This table presents the estimation for Eq. (2) in two subsamples: high and low regional mobility. The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. $Regional\ mobility^{high}$ equals 1 when the proportion of registered residents working outside the village or community for more than three months is equal to or greater than 10%, and 0 otherwise. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. *, **, *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	Regional_ $mobility^{high}$=0	Regional_ $mobility^{high}$=1	Regional_ $mobility^{high}$=0	Regional_ $mobility^{high}$=1
	(1)	(2)	(3)	(4)
Panel A Health status				
$Health^{fair}$	0.0522	0.0529**	0.0646	0.134**
	(0.0370)	(0.0227)	(0.0654)	(0.0527)
$Health^{good}$	0.0218	0.0567**	0.0218	0.200***
	(0.0403)	(0.0238)	(0.0852)	(0.0635)
$Health^{fair}$ × Number_of_children	-0.0217	-0.0310***	-0.0235	-0.0406**
	(0.0150)	(0.00881)	(0.0247)	(0.0192)
$Health^{good}$ × Number_of_children	-0.0132	-0.0378***	0.00647	-0.0432*
	(0.0181)	(0.0116)	(0.0321)	(0.0226)
Number_of_children	0.0141	0.0221***	-0.0336*	-0.0205
	(0.0134)	(0.00708)	(0.0200)	(0.0148)
Observations	4,054	8,324	3,126	6,571
(Pseudo) R^2	0.201	0.185	0.389	0.167
Panel B Chronic disease				
Chronic_diseases	-0.00928	-0.0189***	0.00986	-0.0509***
	(0.00891)	(0.00658)	(0.0173)	(0.0161)
Chronic_diseases × Number_of_children	0.00388	0.0107***	-0.00223	0.0185***
	(0.00356)	(0.00255)	(0.00597)	(0.00635)
Number_of_children	-0.00518	-0.0164***	-0.0401**	-0.0800***
	(0.00859)	(0.00545)	(0.0181)	(0.0129)
Observations	4,056	8,323	3,127	6,570
(Pseudo) R^2	0.201	0.186	0.389	0.167
Panel C Health risk				
Health_risk	-0.0912	-0.122**	-0.100	-0.403***
	(0.0905)	(0.0538)	(0.162)	(0.126)
Health_risk × Number_of_children	0.0455	0.0729***	0.0226	0.106**
	(0.0366)	(0.0207)	(0.0615)	(0.0456)
Number_of_children	-0.0118	-0.0211***	-0.0495**	-0.0797***
	(0.0114)	(0.00707)	(0.0225)	(0.0158)
Observations	4,054	8,322	3,126	6,570
(Pseudo) R^2	0.201	0.185	0.388	0.166
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 10 Heterogeneous impact of informal insurance (regional development level)

This table presents the estimation for Eq. (2) in two subsamples: middle/western provinces and eastern provinces. The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. *Eastern_provinces* equals 1 when the individual's registered residence is among the 11 eastern provinces (Beijing, Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, or Hainan) in China, and 0 otherwise. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. $*$, $**$, $***$ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	Eastern_ provinces=0	Eastern_ provinces=1	Eastern_ provinces=0	Eastern_ provinces=1
	(1)	(2)	(3)	(4)
Panel A Health status				
$Health^{fair}$	0.0354	0.0401	0.176***	-0.0428
	(0.0236)	(0.0345)	(0.0535)	(0.0864)
$Health^{good}$	0.0472*	0.0299	0.254***	-0.0118
	(0.0258)	(0.0361)	(0.0708)	(0.0948)
$Health^{fair}$ × Number_of_children	-0.0226**	-0.0231	-0.0569***	0.0210
	(0.00884)	(0.0152)	(0.0192)	(0.0339)
$Health^{good}$ × Number_of_children	-0.0300***	-0.0234	-0.0588**	0.0404
	(0.0114)	(0.0176)	(0.0247)	(0.0369)
Number_of_children	0.0230***	0.00886	-0.0303**	-0.111***
	(0.00724)	(0.0132)	(0.0144)	(0.0272)
Observations	9,762	4,560	7,426	3,362
(Pseudo) R^2	0.207	0.150	0.191	0.239
Panel B Chronic disease				
Chronic_diseases	-0.0102*	-0.00804	-0.0360**	-0.0439
	(0.00610)	(0.00794)	(0.0141)	(0.0269)
Chronic_diseases × Number_of_children	0.00693***	0.00336	0.0110**	0.0168
	(0.00225)	(0.00356)	(0.00503)	(0.0121)
Number_of_children	-0.00617	-0.0126*	-0.0899***	-0.112***
	(0.00549)	(0.00728)	(0.0135)	(0.0209)
Observations	9,763	4,560	7,426	3,362
(Pseudo) R^2	0.208	0.149	0.189	0.239
Panel C Health risk				
Health_risk	-0.0782	-0.0664	-0.485***	0.0772
	(0.0567)	(0.0818)	(0.130)	(0.206)
Health_risk × Number_of_children	0.0519**	0.0542	0.141***	-0.0721
	(0.0210)	(0.0357)	(0.0465)	(0.0777)
Number_of_children	-0.00919	-0.0219**	-0.111***	-0.0716***
	(0.00721)	(0.0103)	(0.0167)	(0.0263)
Observations	9,760	4,559	7,425	3,362
(Pseudo) R^2	0.207	0.150	0.190	0.238
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 11 Income as alternative explanation

This table presents the results to verify whether net income and net labor income have the similar substitution effects on pension as informal insurance does based on Eq. (2). The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Labor_income* is the sum of the individual's wage income, individual-based transfers, net agricultural income per capita, net livestock income per capita, and net income from self-employed activities per capita. *Net_income* includes *Labor_income*, income from a house/apartment and/or land rent per capita, and household public transfer income per capita. *Ln(Net_income)* and *Ln(Labor_income)* are used as moderators to interact with the health cost risk measures. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	(1)	(2)	(3)	(4)
Moderator	Ln(Net_income)	Ln(Labor_income)	Ln(Net_income)	Ln(Labor_income)
Panel A Health status				
$Health^{fair}$	-0.0209	-0.0241**	0.0630**	0.0618**
	(0.0134)	(0.0115)	(0.0279)	(0.0256)
$Health^{good}$	-0.0259	-0.0150	0.102***	0.117***
	(0.0162)	(0.0145)	(0.0372)	(0.0347)
$Health^{fair}$ × *Moderator*	0.000640	0.00132	-0.00571	-0.00654*
	(0.00179)	(0.00176)	(0.00378)	(0.00386)
$Health^{good}$ × *Moderator*	0.000911	-0.000884	0.000141	-0.00261
	(0.00204)	(0.00205)	(0.00483)	(0.00494)
Moderator	0.000460	0.000904	0.00194	0.000519
	(0.00145)	(0.00145)	(0.00292)	(0.00321)
Observations	14,319	14,319	10,787	10,787
(Pseudo) R^2	0.186	0.185	0.215	0.216
Panel B Chronic disease				
Chronic_diseases	0.00578*	0.00293	-0.0153**	-0.0196***
	(0.00331)	(0.00310)	(0.00755)	(0.00708)
Chronic_diseases × *Moderator*	-0.000128	0.000447	0.00101	0.00203*
	(0.000431)	(0.000462)	(0.00100)	(0.00108)
Moderator	0.00116	0.000644	-0.00213	-0.00608**
	(0.000961)	(0.000987)	(0.00253)	(0.00259)
Observations	14,320	14,320	10,787	10,787
(Pseudo) R^2	0.185	0.185	0.214	0.214
Panel C Health risk				
Health_risk	0.0451	0.0524*	-0.132*	-0.191***
	(0.0325)	(0.0286)	(0.0723)	(0.0638)
Health_risk × *Moderator*	0.000928	0.00105	0.000830	0.00986
	(0.00438)	(0.00432)	(0.00993)	(0.00964)
Moderator	0.000867	0.00135	-0.000959	-0.00649*
	(0.00122)	(0.00133)	(0.00298)	(0.00332)
Observations	14,319	14,319	10,787	10,787
(Pseudo) R^2	0.185	0.185	0.214	0.214
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 12 Property ownership as alternative explanation

This table presents the results to verify whether rental income and property ownership have the similar substitution effects on pension as informal insurance does based on Eq. (2). The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Rental_income* is income from a house/apartment and/or land rent per capita. *Property_ownership* equals 1 when the individual owns land (including collective distributing cultivated land, forest land, pasture, and pond) or a house/apartment, and 0 otherwise. *Ln(Rental_income)* and *Property_ownership* are used as moderators to interact with the health cost risk measures. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	(1)	(2)	(3)	(4)
Moderator	Ln(Rental_income)	Property_ownership	Ln(Rental_income)	Property_ownership
Panel A Health status				
$Health^{fair}$	-0.0165*	-0.0566	0.0247	0.236
	(0.00842)	(0.0512)	(0.0183)	(0.200)
$Health^{good}$	-0.0262**	-0.0777	0.0995***	0.230
	(0.0105)	(0.0655)	(0.0242)	(0.235)
$Health^{fair}$ × *Moderator*	0.00184	0.0403	0.00385	-0.210
	(0.00346)	(0.0517)	(0.00837)	(0.200)
$Health^{good}$ × *Moderator*	0.00771*	0.0587	0.00358	-0.127
	(0.00398)	(0.0658)	(0.0103)	(0.235)
Moderator	-0.00733***	0.0615	0.0135**	-0.106
	(0.00278)	(0.0385)	(0.00670)	(0.152)
Observations	14,043	14,289	10,689	10,771
(Pseudo) R^2	0.173	0.186	0.216	0.216
Panel B Chronic disease				
Chronic_diseases	0.00464**	0.00968	-0.0109**	-0.0592
	(0.00231)	(0.0133)	(0.00514)	(0.0390)
Chronic_diseases × *Moderator*	0.0000450	-0.00480	0.00172	0.0512
	(0.000865)	(0.0134)	(0.00208)	(0.0392)
Moderator	-0.00462**	0.102***	0.0140***	-0.328***
	(0.00192)	(0.0325)	(0.00527)	(0.118)
Observations	14,044	14,290	10,689	10,771
(Pseudo) R^2	0.173	0.186	0.214	0.215
Panel C Health risk				
Health_risk	0.0490**	0.166	-0.108**	-0.613
	(0.0212)	(0.125)	(0.0471)	(0.482)
Health_risk × *Moderator*	-0.00777	-0.119	-0.0113	0.495
	(0.0846)	(0.126)	(0.0202)	(0.483)
Moderator	-0.00260	0.126***	0.0191***	-0.371**
	(0.00246)	(0.0434)	(0.00661)	(0.165)
Observations	14,043	14,289	10,689	10,771
(Pseudo) R^2	0.173	0.186	0.214	0.215
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

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Appendix

Appendix A Controlling for income to address endogeneity

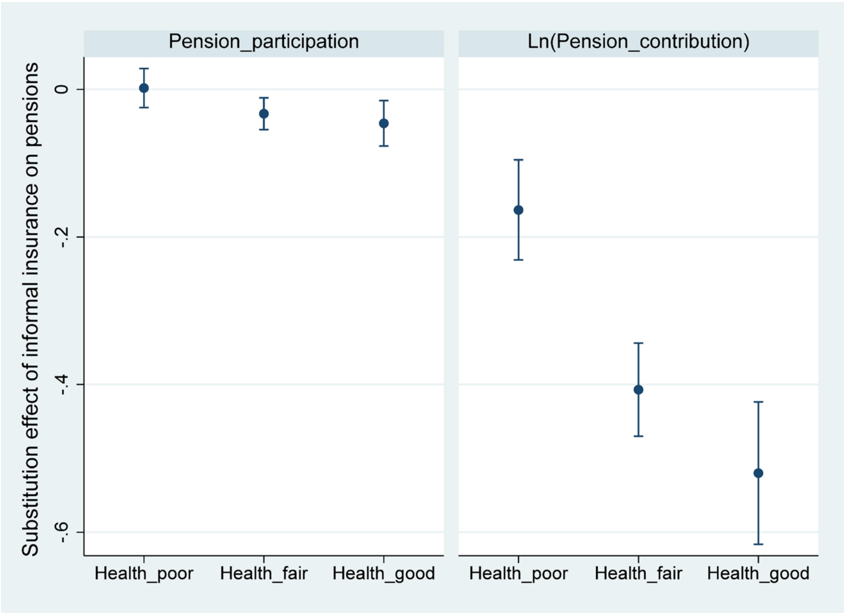
This table reports the regression results controlling for individuals' *Ln(Net_income)* in addition to the households' wealth per capita to address the concern on the omitted variable of income. Panel A presents the estimation for Eq. (1): the impact of health cost risk on pension demand. Panel B presents the estimation for Eq. (2): whether, and to what extent, the availability of informal insurance provided by children mitigates the impact of health cost risk on pension demand. Columns (1)–(3) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Net_income* includes the sum of the individual's wage income, individual-based transfers, net agricultural income per capita, net livestock income per capita, net income from self-employed activities per capita, income from a house/apartment and/or land rent per capita, and household public transfer income per capita. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A Estimating Eq. (1)						
$Health^{fair}$	-0.0172**			0.0291*		
	(0.00802)			(0.0175)		
$Health^{good}$	-0.0203**			0.106***		
	(0.00999)			(0.0230)		
Chronic_diseases		0.00501**			-0.00938*	
		(0.00221)			(0.00484)	
Health_risk			0.0505**			-0.127***
			(0.0205)			(0.0448)
Ln(Net_income)	0.00101	0.000971	0.00107	-0.000852	-0.000567	-0.000777
	(0.000713)	(0.000713)	(0.000711)	(0.00177)	(0.00177)	(0.00177)
Observations	14,319	14,320	14,319	10,787	10,787	10,787
(Pseudo) R^2	0.185	0.185	0.185	0.215	0.214	0.214
Panel B Estimating Eq. (2)						
$Health^{fair}$	0.0395**			0.133***		
	(0.0194)			(0.0457)		
$Health^{good}$	0.0425**			0.208***		
	(0.0207)			(0.0560)		
Chronic_diseases		-0.0102**			-0.0431***	
		(0.00489)			(0.0126)	
Health_risk			-0.0778*			-0.385***
			(0.0464)			(0.111)
$Health^{fair}$ × Number_of_children	-0.0245***			-0.0438***		
	(0.00762)			(0.0167)		
$Health^{good}$ × Number_of_children	-0.0295***			-0.0435**		
	(0.00945)			(0.0202)		
Chronic_diseases × Number_of_children		0.00657***			0.0141***	
		(0.00191)			(0.00480)	
Health_risk × Number_of_children			0.0555***			0.108***
			(0.0180)			(0.0400)
Number_of_children	0.0202***	-0.00850*	-0.0136**	-0.0453***	-0.101***	-0.107***
	(0.00635)	(0.00439)	(0.00590)	(0.0128)	(0.0114)	(0.0143)
Ln(Net_income)	0.000985	0.000955	0.00101	-0.000905	-0.000605	-0.000909
	(0.000712)	(0.000713)	(0.000710)	(0.00177)	(0.00177)	(0.00177)
Observations	14,319	14,320	14,319	10,787	10,787	10,787
(Pseudo) R^2	0.186	0.186	0.186	0.216	0.214	0.214
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Appendix B Robustness checks

Figure B1 Substitution effect of informal insurance on pensions in respective health status

Figure B1 presents the impact of an individual's subjective beliefs about relying on their children for old-age support on the individuals' pension demand under the poor, fair, and good health statuses (i.e., the average marginal effects of *Rely_on_children* at respective health status after regression reported in Columns (1) and (4), Appendix B3). *Pension_participation* is the dependent variable in Column (1) of Appendix B3, which is a dummy variable that equals 1 when individuals participated in the RBP program. *Ln(Pension_contribution)* is the dependent variable in Column (4) of Appendix B3, which is a log form continuous variable representing the annual contributions that individuals paid to the RBP program. $Health^{poor}$ equals 1 when the self-reported health status is very poor or poor, and 0 otherwise. $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. *Rely_on_children* equals 1 when the individual expects children to be his/her main financial resource in old-age, and 0 when the individual expects savings, public or private pensions, or other financial resources as the main financial resource for old age. As shown in Figure B1, the better the health status (i.e., the lower the health cost risk), the greater the substitution effect of an individual's subjective beliefs about relying on their children for old-age support on pensions.



Appendix B1 Income and property ownership as alternative explanations

This table presents the *t*-test results of *Net_income* (Panel A), *Labor_income* (Panel B), *Rental_income* (Panel C), and *Property_ownership* (Panel D) between RBP participants and nonparticipants in different self-reported health statuses, respectively. *Labor_income* is the sum of the individual's wage income, individual-based transfers, net agricultural income per capita, net livestock income per capita, and net income from self-employed activities per capita. *Rental_income* is income from a house/apartment and/or land rent per capita. *Net_income* includes *Labor_income*, *Rental_income*, and household public transfer income per capita. *Property_ownership* equals 1 when the individual owns land (including collective distributing cultivated land, forest land, pasture, and pond) or a house/apartment, and 0 otherwise. The average *Net_income*, *Labor_income*, and *Rental_income* are not significantly different between RBP participants and nonparticipants. The rate of property ownership is higher among the RBP participants than the nonparticipants, which is contrary to the argument that properties substitute for pensions. The results again exclude the alternative explanations of income and property ownership for the opposite health cost risk impact on pension participation and pension contribution.

		Obs.	Mean	Std.	Mean-diff.	p-value (t-test)
Panel A Net_income						
$Health^{poor}$	Participants	2,737	4,996.22	12,788.07	265.40	0.6183
	Nonparticipants	685	4,730.82	11,082.55		
$Health^{fair}$	Participants	5,703	9,287.06	19,043.98	-274.59	0.6329
	Nonparticipants	1,487	9,561.65	22,223.73		
$Health^{good}$	Participants	2,936	12,612.81	22,895.80	-981.09	0.2980
	Non-participants	771	13,593.90	24,732.61		
Panel B Labor_income						
$Health^{poor}$	Participants	2,737	4,185.29	11,273.42	595.16	0.2074
	Nonparticipants	685	3,590.13	10,100.43		
$Health^{fair}$	Participants	5,703	8,388.93	17,119.67	19.05	0.9702
	Nonparticipants	1,487	8,369.87	18,994.91		
$Health^{good}$	Participants	2,936	11,357.68	20,288.34	-1502.23	0.0760
	Non-participants	771	12,859.91	23,160.36		
Panel C Rental_income						
$Health^{poor}$	Participants	2,712	160.23	996.80	-76.91	0.1108
	Nonparticipants	642	237.14	1,452.76		
$Health^{fair}$	Participants	5,653	227.90	1,448.43	-65.92	0.1445
	Nonparticipants	1,403	293.82	1,754.23		
$Health^{good}$	Participants	2,906	285.96	1,600.88	-15.25	0.8255
	Nonparticipants	727	301.21	1,911.81		
Panel D Property_ownership						
$Health^{poor}$	Participants	2,734	0.98	0.14	0.038	0.0000
	Nonparticipants	681	0.94	0.23		
$Health^{fair}$	Participants	5,693	0.98	0.12	0.032	0.0000
	Nonparticipants	1,482	0.95	0.21		
$Health^{good}$	Participants	2,930	0.98	0.12	0.036	0.0000
	Nonparticipants	769	0.95	0.22		

Appendix B2 Impact of health cost risk on pension contributions (full sample)

This table reports the coefficients of the Tobit regressions using the full sample including both RBP participants and nonparticipants. The dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*), in which nonparticipants have zero contributions. Columns (1)–(3) report the results estimating Eq. (1). Columns (4)–(6) report the results estimating Eq. (2). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. *, **, *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Ln(Pension_contribution)					
	(1)	(2)	(3)	(4)	(5)	(6)
$Health^{fair}$	-0.0981*			0.356**		
	(0.0565)			(0.142)		
$Health^{good}$	-0.0392			0.513***		
	(0.0699)			(0.167)		
Chronic_diseases		0.0223			-0.0938***	
		(0.0151)			(0.0338)	
Health_risk			0.235			-0.846**
			(0.145)			(0.342)
$Health^{fair}$ × Number_of_children				-0.193***		
				(0.0528)		
$Health^{good}$ × Number_of_children				-0.240***		
				(0.0635)		
Chronic_diseases × Number_of_children					0.0494***	
					(0.0122)	
Health_risk × Number_of_children						0.462***
						(0.124)
Number_of_children	-0.0189	-0.0207	-0.0196	0.131***	-0.100***	-0.146***
	(0.0239)	(0.0239)	(0.0238)	(0.0420)	(0.0327)	(0.0426)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,732	13,733	13,730	13,732	13,733	13,730
Pseudo R^2	0.050	0.050	0.050	0.051	0.051	0.051

Appendix B3 Substitution effect of informal insurance on pensions (*Rely_on_children*)

This table presents the estimation for Eq. (2) using *Rely_on_children* as an alternative measure of informal insurance, to investigate whether, and to what extent, the availability of informal insurance provided by children mitigates the impact of health cost risk on pension demand. Columns (1)–(3) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Rely_on_children* equals 1 when the individual expects children to be his/her main financial resource in old-age, and 0 when the individual expects savings, public or private pensions, or other financial resources as the main financial resource for old age. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. *, **, *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Health^{fair}$	0.00240			0.171***		
	(0.0143)			(0.0434)		
$Health^{good}$	0.00408			0.306***		
	(0.0162)			(0.0536)		
Chronic_diseases		-0.00262			-0.0406***	
		(0.00359)			(0.0109)	
Health_risk			-0.00913			-0.589***
			(0.0346)			(0.105)
$Health^{fair}$ × Rely_on_children	-0.0261			-0.174***		
	(0.0166)			(0.0454)		
$Health^{good}$ × Rely_on_children	-0.0350*			-0.269***		
	(0.0189)			(0.0561)		
Chronic_diseases × Rely_on_children		0.0104**			0.0397***	
		(0.00424)			(0.0116)	
Health_risk × Rely_on_children			0.0765*			0.587***
			(0.0395)			(0.109)
Rely_on_children	0.00185	-0.0351***	-0.0390***	-0.163***	-0.384***	-0.471***
	(0.0135)	(0.00935)	(0.0122)	(0.0346)	(0.0287)	(0.0369)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,892	13,893	13,889	10,480	10,480	10,479
(Pseudo) R^2	0.186	0.186	0.186	0.236	0.234	0.235

Appendix B4 Substitution effect of informal insurance on pensions

This table presents the estimation for Eq. (2) using *Ln(Number_of_children)* to capture the potential nonlinear impact of *Number_of_children*. Columns (1)–(3) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. *, **, *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Health^{fair}$	0.0856***			0.190**		
	(0.0287)			(0.0750)		
$Health^{good}$	0.0788***			0.247***		
	(0.0292)			(0.0923)		
Chronic_diseases		-0.0180**			-0.0661***	
		(0.00736)			(0.0190)	
Health_risk			-0.173**			-0.479***
			(0.0690)			(0.182)
$Health^{fair}$ × Ln(Number_of_children)	-0.0854***			-0.138**		
	(0.0231)			(0.0595)		
$Health^{good}$ × Ln(Number_of_children)	-0.0951***			-0.121*		
	(0.0311)			(0.0734)		
Chronic_diseases × Ln(Number_of_children)		0.0190***			0.0485***	
		(0.00593)			(0.0153)	
Health_risk × Ln(Number_of_children)			0.185***			0.301**
			(0.0559)			(0.144)
Ln(Number_of_children)	0.0718***	-0.0211	-0.0423**	-0.188***	-0.363***	-0.367***
	(0.0188)	(0.0142)	(0.0189)	(0.0474)	(0.0385)	(0.0495)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,322	14,323	14,319	10,788	10,788	10,787
(Pseudo) R^2	0.186	0.186	0.186	0.217	0.216	0.216

Appendix B5 Heterogeneous impact of informal insurance (rural versus urban areas)

This table presents the estimation for Eq. (2) in two subsamples: rural and urban areas. The results are based on different health cost risk measures, including self-reported health statuses (Panel A), chronic diseases (Panel B) and health risk (Panel C). Columns (1)–(2) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (3)–(4) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. *Urban* equals 1 when the individual's registered residence (*hukou*) is urban, and 0 when the individual's registered residence is rural. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. *, **, *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation		Ln(Pension_contribution)	
	Urban = 0	Urban = 1	Urban = 0	Urban = 1
	(1)	(2)	(3)	(4)
Panel A Health status				
$Health^{fair}$	0.0424**	0.00826	0.127***	0.749*
	(0.0199)	(0.0799)	(0.0422)	(0.413)
$Health^{good}$	0.0409*	0.0940	0.189***	0.452
	(0.0213)	(0.0849)	(0.0518)	(0.465)
$Health^{fair}$ × Number_of_children	-0.0258***	-0.00532	-0.0421***	-0.155
	(0.00782)	(0.0331)	(0.0157)	(0.153)
$Health^{good}$ × Number_of_children	-0.0284***	-0.0372	-0.0411**	0.00896
	(0.00983)	(0.0366)	(0.0189)	(0.195)
Number_of_children	0.0200***	0.0277	-0.0296**	-0.316**
	(0.00652)	(0.0300)	(0.0119)	(0.134)
Observations	13,312	995	10,370	418
(Pseudo) R^2	0.165	0.248	0.188	0.443
Panel B Chronic disease				
Chronic_diseases	-0.0121**	0.00513	-0.0380***	-0.154*
	(0.00517)	(0.0180)	(0.0121)	(0.0877)
Chronic_diseases × Number_of_children	0.00737***	-0.00421	0.0133***	0.0524*
	(0.00203)	(0.00656)	(0.00465)	(0.0270)
Number_of_children	-0.00980**	0.0198	-0.0821***	-0.513***
	(0.00450)	(0.0187)	(0.0109)	(0.106)
Observations	13,313	995	10,370	418
(Pseudo) R^2	0.165	0.247	0.186	0.438
Panel C Health risk				
Health_risk	-0.0832*	-0.0659	-0.376***	-1.699*
	(0.0476)	(0.195)	(0.103)	(1.012)
Health_risk × Number_of_children	0.0564***	0.0369	0.104***	0.323
	(0.0185)	(0.0805)	(0.0377)	(0.373)
Number_of_children	-0.0142**	0.00273	-0.0887***	-0.483***
	(0.00603)	(0.0246)	(0.0135)	(0.128)
Observations	13,309	995	10,369	418
(Pseudo) R^2	0.165	0.246	0.187	0.440
Control variables	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Appendix B6 Controlling for living parent

This table reports the regression results controlling for whether the respondent has at least one living parent. Panel A presents the estimation for Eq. (1): the impact of health cost risk on pension demand. Panel B presents the estimation for Eq. (2): whether, and to what extent, the availability of informal insurance provided by children mitigates the impact of health cost risk on pension demand. Columns (1)–(3) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. *Living_parent* equals 1 when the respondent has at least one living parent (i.e., biological father, biological mother, stepfather, or stepmother), and 0 otherwise. The standard set of control variables are the same as those in Table 2. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A Estimating Eq. (1)						
$Health^{fair}$	-0.0171**			0.0281		
	(0.00802)			(0.0174)		
$Health^{good}$	-0.0198**			0.106***		
	(0.00998)			(0.0229)		
Chronic_diseases		0.00487**			-0.00947*	
		(0.00220)			(0.00483)	
Health_risk			0.0483**			-0.124***
			(0.0204)			(0.0449)
Living_parent	0.00221	0.00193	0.00216	0.0450***	0.0439***	0.0431***
	(0.00684)	(0.00683)	(0.00684)	(0.0157)	(0.0157)	(0.0157)
Observations	14,312	14,313	14,309	10,781	10,781	10,780
(Pseudo) R^2	0.185	0.185	0.185	0.216	0.214	0.214
Panel B Estimating Eq. (2)						
$Health^{fair}$	0.0396**			0.132***		
	(0.0194)			(0.0456)		
$Health^{good}$	0.0433**			0.208***		
	(0.0207)			(0.0560)		
Chronic_diseases		-0.0104**			-0.0435***	
		(0.00489)			(0.0127)	
Health_risk			-0.0817*			-0.382***
			(0.0464)			(0.111)
$Health^{fair}$ × Number_of_children	-0.0244***			-0.0436***		
	(0.00762)			(0.0167)		
$Health^{good}$ × Number_of_children	-0.0296***			-0.0437**		
	(0.00945)			(0.0202)		
Chronic_diseases × Number_of_children		0.00660***			0.0143***	
		(0.00191)			(0.00481)	
Health_risk × Number_of_children			0.0562***			0.108***
			(0.0180)			(0.0401)
Number_of_children	0.0203***	-0.00842*	-0.0136**	-0.0456***	-0.101***	-0.108***
	(0.00635)	(0.00439)	(0.00589)	(0.0128)	(0.0114)	(0.0143)
Living_parent	0.00194	0.00186	0.00191	0.0451***	0.0447***	0.0432***
	(0.00684)	(0.00683)	(0.00684)	(0.0157)	(0.0157)	(0.0157)
Observations	14,312	14,313	14,309	10,781	10,781	10,780
(Pseudo) R^2	0.186	0.186	0.186	0.216	0.215	0.215
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Appendix B7 Standard errors clustered at household level

This table reports the regression results with standard errors clustered at household level. Panel A presents the estimation for Eq. (1): the impact of health cost risk on pension demand. Panel B presents the estimation for Eq. (2): whether, and to what extent, the availability of informal insurance provided by children mitigates the impact of health cost risk on pension demand. Columns (1)–(3) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Number_of_children* is the number of the individual's living children. The standard set of control variables are the same as those in Table 2. $*$, $**$, $***$ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A Estimating Eq. (1)						
$Health^{fair}$	-0.0170**			0.0287		
	(0.00848)			(0.0192)		
$Health^{good}$	-0.0200*			0.105***		
	(0.0107)			(0.0255)		
Chronic_diseases		0.00491*			-0.00935[a]	
		(0.00269)			(0.00582)	
Health_risk			0.0484**			-0.126**
			(0.0218)			(0.0499)
Observations	14,322	14,323	14,319	10,788	10,788	10,787
(Pseudo) R^2	0.185	0.185	0.185	0.215	0.214	0.214
Panel B Estimating Eq. (2)						
$Health^{fair}$	0.0397**			0.132***		
	(0.0201)			(0.0500)		
$Health^{good}$	0.0428*			0.208***		
	(0.0220)			(0.0640)		
Chronic_diseases		-0.0103*			-0.0430***	
		(0.00581)			(0.0153)	
Health_risk			-0.0814[b]			-0.382***
			(0.0497)			(0.127)
$Health^{fair}$ × Number_of_children	-0.0245***			-0.0436**		
	(0.00789)			(0.0178)		
$Health^{good}$ × Number_of_children	-0.0295***			-0.0434*		
	(0.00998)			(0.0232)		
Chronic_diseases × Number_of_children		0.00658***			0.0141**	
		(0.00230)			(0.00594)	
Health_risk × Number_of_children			0.0562***			0.108**
			(0.0192)			(0.0461)
Number_of_children	0.0201***	-0.00857	-0.0138**	-0.0454***	-0.101***	-0.107***
	(0.00709)	(0.00561)	(0.00694)	(0.0153)	(0.0151)	(0.0179)
Observations	14,322	14,323	14,319	10,788	10,788	10,787
(Pseudo) R^2	0.186	0.186	0.186	0.216	0.214	0.214
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: a) p-value is 0.108; b) p-value is 0.101.

Appendix B8 Age as an alternative explanation

This table presents the results to verify whether age has the similar substitution effects on pensions as informal insurance does based on Eq. (2). Columns (1)–(3) report the average marginal effects of the Probit regressions, in which the dependent variable is a dummy variable that equals 1 when individuals participated in the RBP program (*Pension_participation*). Columns (4)–(6) report the coefficients of the OLS regressions, in which the dependent variable is a log form continuous variable representing the annual contributions that individuals paid to the RBP program (*Ln(Pension_contribution)*). $Health^{fair}$ equals 1 when the self-reported health status is fair, and 0 otherwise. $Health^{good}$ equals 1 when the self-reported health status is good, very good, or excellent, and 0 otherwise. The omitted group is the individuals whose self-reported health status are very poor or poor. *Chronic_diseases* is measured by the number of chronic diseases that the individual has been diagnosed with. *Health_risk* is a continuous variable from 0 to 1, measuring an individual's predicated probability of being in a poor health in five years or deceased within five years. *Age50–54* equals 1 when the individual' s age is between 50-54 years old, and 0 otherwise. *Age55–59* equals 1 when the individual' s age is between 55-59 years old, and 0 otherwise. The standard set of control variables are the same as those in Table 2 except for *Age*. Robust standard errors are provided in parentheses. ∗, ∗∗, ∗∗∗ represent statistical significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	Pension_participation			Ln(Pension_contribution)		
	(1)	(2)	(3)	(4)	(5)	(6)
$Health^{fair}$	-0.0157			0.0106		
	(0.0160)			(0.0353)		
$Health^{good}$	-0.0401**			0.0928**		
	(0.0189)			(0.0452)		
Chronic_diseases		0.00837*			-0.0126	
		(0.00444)			(0.0105)	
Health_risk			0.0531			-0.0721
			(0.0380)			(0.0869)
$Health^{fair}$ × Age50–54	-0.00170			0.0347		
	(0.0185)			(0.0430)		
$Health^{good}$ × Age50–54	0.0239			0.0471		
	(0.0213)			(0.0557)		
$Health^{fair}$ × Age55–59	-0.00360			0.0145		
	(0.0180)			(0.0425)		
$Health^{good}$ × Age55–59	0.0243			-0.0167		
	(0.0210)			(0.0544)		
Chronic_diseases × Age50–54		-0.00401			-0.00699	
		(0.00505)			(0.0124)	
Chronic_diseases × Age55–59		-0.00341			0.0142	
		(0.00496)			(0.0124)	
Health_risk × Age50–54			-0.00754			-0.116
			(0.0445)			(0.107)
Health_risk × Age55–59			0.00909			-0.0251
			(0.0436)			(0.105)
Age50–54	0.0181	0.0280***	0.0252*	-0.0121	0.0298	0.0447
	(0.0150)	(0.0100)	(0.0131)	(0.0351)	(0.0268)	(0.0333)
Age55–59	0.0529***	0.0608***	0.0522***	0.0302	0.0110	0.0421
	(0.0145)	(0.0102)	(0.0139)	(0.0344)	(0.0269)	(0.0349)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,322	14,323	14,319	10,788	10,788	10,787
(Pseudo) R^2	0.184	0.184	0.184	0.215	0.214	0.214