China's High Savings Rate Puzzle: Role of Precautionary Saving

Yao Dongmin (姚东旻)[1*], Xu Yixuan (许艺煊)[2] and Zhang Pengyuan (张鹏远)[3]

[1,3] Center For China Fiscal Development , Central University of Finance and Economics (CUFE), Beijing, China

[2] School of Economics, Renmin University of China (RUC), Beijing

Abstract: *Academics have yet to agree on the effectiveness of the precautionary saving theory in explaining Chinese households' saving behavior. With the Wenchuan mega-earthquake of 2008 as an uncertain event to overcome the endogeneity problem of income volatility, this paper puts forward a brand-new hypothesis that "an earthquake influences household saving rate through its effects on expected income and the variance of expected income." Then, we employ propensity score matching - difference-in-differences (PSM-DID) method, the systematic GMM methods, the synthetic control method, together with instrumental variable method, for an analysis of Chinese Household Income Project (CHIP) and inter-provincial data at the micro and macro levels, respectively. We find that the Wenchuan mega-earthquake was followed by an increase in the variance of household expected income in Sichuan and a significant rise in the household saving rate. Second, social protection is negatively correlated with expected income, and has a significant substitutive relationship with saving rate. This finding indirectly proves that the earthquake's impact on the household saving rate is subject to the variance of expected income, shedding light on how the precautionary saving motivation works in the real world.*

Keywords: *precautionary saving, income uncertainty, household savings rate, natural disaster*

JEL Classification Codes: D14, E21, H53

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1. Introduction

Over the past four decades, China has established a complete social safety net, including pension, disaster relief, and healthcare, amid steady advances in market-based reforms and the market-based economy. Despite these developments, however, a high savings rate has co-existed with flagging household consumption in China - a phenomenon described by Chinese and international academics as the "high savings rate puzzle." In fact, Chinese households' propensity to save explains the lack of consumption. In the late 1960s, Leland (1968) put forward a theory of precautionary savings in an attempt to explain individual consumption and excessive savings from the perspective of uncertainty. He defines precautionary saving as "additional saving due to uncertain future incomes." Afterwards, a large body of empirical research has verified the motivation of precautionary saving that exists in the real world. The question is whether precautionary saving may explain Chinese households' "excessive savings"? In more general terms, what is the real explanatory power of the precautionary saving theory? Studies based on different data and

* Corresponding author: Yao Dongmin, email: yaodongminn@163.com

methodologies have led to different conclusions.[1]

Hence, this paper introduces the uncertainty of an earthquake to answer the above questions with Chinese households' savings behavior as a case study. First, the earthquake as the background of our empirical study corresponds to uncertainty in the theoretical sense. Although earthquakes are not entirely random, with current disaster forecast technology, we are still unable to predict precisely when and where an earthquake will strike. We cannot even measure the probability of an earthquake in a specific region at a certain point in time. Second, previous studies have neglected the essential problem of "endogeneity that usually exists in household income volatility."[2] Yet the stochastic nature of income volatility resulting from an earthquake effectively overcomes this problem.

In this paper's theoretical section, we construct a three-phase precautionary saving decision model to solve and predict possible change in household savings rate following an earthquake. We find that "an earthquake influences household savings rate through its effects on expected income and the variance of expected income," which is explained with numerical simulation. Concerning the empirical test, this paper introduces the 8.0 Richter scale mega-earthquake that hit Wenchuan County in China's Sichuan Province in 2008 to verify the theoretic path of effects in direct and indirect ways based on Chinese household survey data and inter-provincial data, respectively. This paper may offer the following contributions. First, it verifies the real explanatory power of the precautionary saving theory with macro and microdata, and offers science-based and reliable evidence from China, helping resolve controversies over the measurement of the importance of precautionary saving.[3] Second, we combine direct path test with indirect studies on the variance of expected income, and employ various causal inference methodologies to determine how an earthquake influences household savings rate through effects on expected income and its variance. Lastly, this paper explains the motivations behind precautionary saving as an answer to the "high savings rate puzzle."

The rest of this paper is structured as follows: Part 2 Literature review; Part 3 Theoretical analysis and numerical simulation of the precautionary saving model, in which we elaborate an important theoretical path of this paper; Part 4 Empirical analysis; and lastly, conclusions and policy implications.

2. Literature Review

In the 1970s, Western consumption theories started to incorporate uncertainty and risk into modeling, and, based on the results of the rational expectation school, developed consumption function theories under uncertain conditions. Among them, the theory of precautionary saving explains the "excessive saving" phenomenon by introducing uncertainty into the mainstream expected utility framework, and is widely applied in studies on saving behavior over the past two decades. Precautionary motivation is recognized universally in the academic, but its explanatory power remains controversial.

Studies on the extent to which the precautionary saving theory may explain real saving behavior in a country led to different conclusions. Caballero (1990) and Skinner (1988) estimate US precautionary saving as a share of total saving, and arrive at the results of 56% and 60%, respectively. Their findings suggest that the precautionary saving theory largely explains the US household saving behavior. Yet surprisingly, with the uncertain personal assets of households as a measurement of uncertain incomes, Guiso *et al.* (1992) find that precautionary saving motivation only accounts for 2% of household net assets. Based on the Health and Retirement Study (HRS), Lusardi (1998) finds that the US household precautionary saving only represents 1%-3.5% of overall wealth accumulation. Based on a study on

[1] Controversies of research conclusions are not only found in studies on China's household saving, but widely exist in studies on developed countries like the US, Italy and Germany.

[2] For instance, household consumption habits may also influence change in income.

[3] Importance means to what extent motivations for precautionary saving explain real household saving behaviors.

Italian households, Ventura and Eisenhauer (2006) find that precautionary saving accounts for 15%-36% of total household savings. In contrast, Guiso *et al*. (1992) discover from the Italian SHIW database that precautionary saving only makes up a tiny share of overall wealth. In his study on Germany, Bartzsch (2008) finds that precautionary saving accounts for about 20% of total household savings. With German unification as a "natural experiment," Fuchsschündeln and Schündeln (2005) find that before German unification, precautionary saving made up 22% of total savings in East Germany, and precautionary saving in West Germany was roughly half that of East Germany. After German unification, the percentage of precautionary saving declined. With the amendment of German nationality law as a natural experiment, however, Piracha and Zhu (2012) find that the enactment of the new nationality law led to an 80% reduction in the difference between the marginal propensities of local residents and migrants to save. This finding shows that precautionary saving arising from uncertain income prospects and legal status largely explain German residents' saving behavior.

Over the years, China's household savings rate has exceeded those of countries like the United States, Italy and Germany, indicating a higher degree of "excessive saving." Will the precautionary saving theory explain China's household savings rate puzzle? Based on an empirical study of the dynamic model, Lei and Zhang (2013) uncover that precautionary saving accounts for 20%-40% of per capita financial assets in China. With CHNS data, Choi *et al*. (2017) employs recursive utility function for simulation, and finds that precautionary saving makes up over 80% of China's household savings. Song and Zang (2016) further compare the precautionary savings of China's urban and rural residents. Based on the buffer stock model, they uncover that precautionary saving may explain Chinese households' saving, and that rural residents' precautionary saving is eight percentage points higher compared with overall samples.

Yet some studies point to the limited effect of precautionary saving: Based on 1993-2003 data for 35 large and medium-sized Chinese cities, Shi and Zhu (2004) consider that precautionary saving motivation is over-estimated in literature. Li and Zang (2011) stress that previous studies have confused risk with uncertainty: It is uncertainty rather than risk that prompts precautionary saving. Based on the VAR model, they have investigated the saving behavior of Chinese urban households from 1978-2008, and discover that although precautionary saving motivation exists in urban households' consumption and saving behaviors, such precautionary motivation's effect on saving is limited. After investigating how income shocks influence Chinese households' consumption and how future income uncertainty influences Chinese households' saving, Kraay (2000) finds that the result indicates the precautionary saving theory cannot properly explain the saving behavior of Chinese urban households.

As discussed before, both Chinese and international academics have yet to agree on whether the precautionary saving theory may explain household saving behavior. We may find that (i) relevant studies conduct either an analysis with inter-provincial or national data or a test with household data, and that statistical discrepancies may lead to different results;[4] (ii) risks in the econometric model and confusion about the concept of uncertainty may lead to some deviations in studies on the importance of precautionary saving; (iii) household income volatility is often subject to endogeneity, which tends to be overlooked in previous studies. Given the severity of "excessive saving" in China, it is of both general and specific significance to test the real explanatory power of the precautionary saving theory.

3. Theoretical Model and Numeral Simulation

With an earthquake as research background, this paper creates a three-phase precautionary saving model to solve the optimal saving decisions during various periods of time, identify how an earthquake

[4] Macro-level data are per capita data, i.e. a representative (per capita level) consumer in a certain region is involved in analysis. This method is essentially an individual analysis method. However, consumption and saving decisions in economic activity are normally made by individual households.

influences the household savings rate, and verify the result through numerical simulation. In the form of proposition and inference, we provide the result of theoretical forecast on post-earthquake change in household savings rate for an empirical test.

3.1 Theoretical Model Analysis

As a natural disaster, an earthquake causes depreciation and risk. Residents in an earthquake-hit region will suffer property losses and casualties, i.e. depreciation, and tend to feel pessimistic about their income prospects; second, post-disaster economic aid and job-creating reconstruction will provide opportunities for residents in a disaster-hit region to earn more incomes, i.e. risk. In particular, urban residents are less vulnerable to natural disasters, and may feel sanguine about their income prospects. Aside from income, expected income volatility will also increase after an earthquake. Since local social security and public welfare spending play a significant role in supporting households to deal with income volatility, earthquake-related uncertainty will induce more income volatility in regions without complete social security systems. Based on the above analysis, this paper puts forward the following modeling hypothesis:

Hypothesis: Earthquake will change people's perception of current and future incomes, thus influencing their saving behavior.

Then, we create a three-phase cross-temporal saving model, focusing on how post-earthquake income change will affect the household savings rate. We assume that a decision-maker has three decision-making time points (T=0, 1, 2), his current time being T=0 and that current income y_0 is a fixed value. Naturally, y_1 and y_2 denote post-earthquake income and future income, respectively. The difference is that these two incomes are both subject to the impact of stochastic disturbance and uncertainty. The model assumes that an earthquake strikes at a certain time point between T=0 and T=1, and the time series chart of an actor's lifecycle can be expressed as in Figure 1:

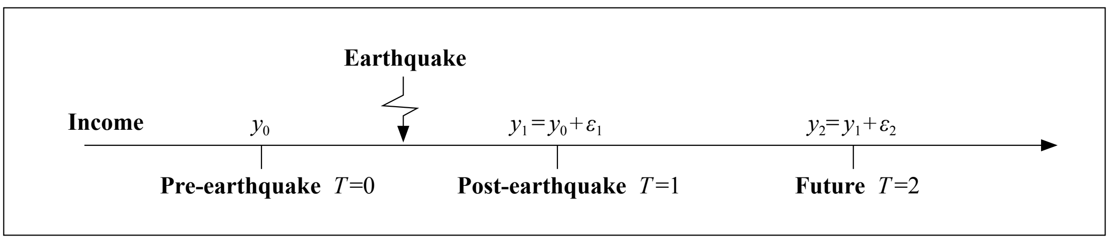

Figure 1: Time Series Chart of an Actor's Lifecycle

Referencing Baiardi's *et al.* (2014) model specifications, this paper specifies an actor's utility function in the precautionary saving model as:

$$\max_{s_t} U_t = E_t\left[\sum_{t=0}^{T}\delta^t \cdot u_t(c_t)\right] \qquad (1)$$
$$s.t. \quad A_{t+1} = R(A_t + y_t - c_t)$$

Where, E_t is mathematical expectation operator; δ is the actor's discount factor; R is market-based interest rate; A_t, y_t and c_t are wealth accumulation, income and consumption at time t, respectively; constraint conditions describes the relationship between the actor's wealth accumulation in the following phase and current-phase saving. For the convenience of analysis, we assume that the actor does not have any initial wealth endowment at the beginning of the lifecycle (A_0=0), and that the actor will consume all his wealth in the last period of the lifecycle (s_2=0). Regarding income specification, this paper follows the assumption[5] in classical literature that income volatility conforms to the random walk hypothesis - at this moment, income uncertainty can be introduced into the model. Based on the model's income specification, we may define the actor's expected income (i.e. mathematical expectation) and the variance of expected income as manifestations of income uncertainty. Further, we may assume the utility function of the actor to be in the CARA form: $u(c)=-e^{-\lambda c}/\lambda$, where $\lambda>0$. Then, the optimal saving ratio of decision-maker in each phase is expressed as equation (2):

$$\begin{cases} sr_0 = \frac{1}{R-1}(\frac{\ln(\delta R)}{\lambda}+\frac{1}{2}\lambda\sigma^2)/y_0 \\ sr_1 = \frac{2-R}{R-1}(\frac{\ln(\delta R)}{\lambda}+\frac{1}{2}\lambda\sigma^2)/(y_0+\varepsilon_1) \end{cases} \quad (2)$$

Judging by the form of the analytical solution of the optimal saving decision, both expected income and its variance will influence the level of the savings rate. Hence, this paper refines the theoretical hypothesis of our modeling and identifies the path through which an earthquake influences an individual's saving decision. By altering an actor's income prospect, specifically his expected income and the variance of expected income,[6] an earthquake will ultimately change the savings rate, as illustrated in Figure 2.

3.2 Numerical Simulation

Since our model's analytical solution contains the stochastic variable of income, it is not appropriate to directly investigate the savings rate effects of expected income and its variance with the method of taking the partial derivative. To test the path through which an earthquake influences the household savings rate, this paper drafts a savings rate probability density distribution chart[7] to compare the mean values and distribution of savings rates under various scenarios through numerical simulation.

Proposition 1: A decrease in expected income will lead to a rise in the savings rate.

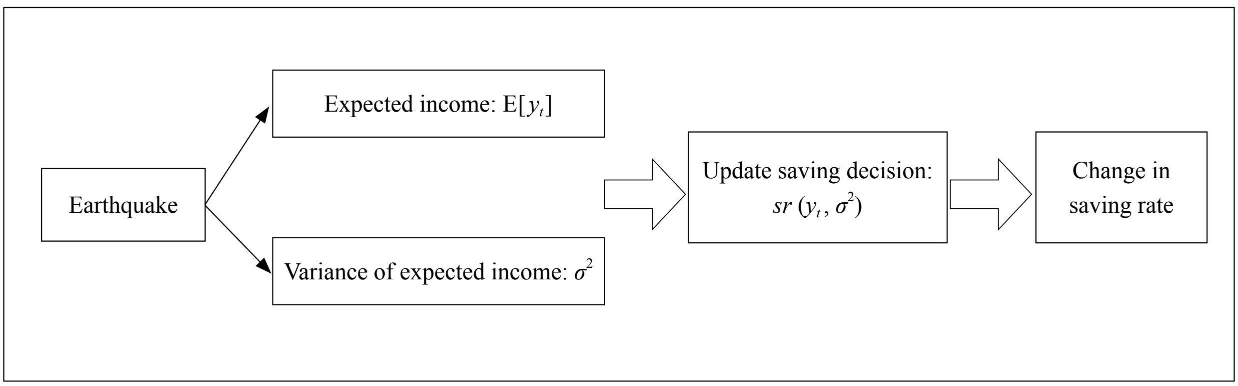

Figure 2: Path of an Earthquake's Influence on Household Saving Rate

[5] Random walk hypothesis: $y_t = y_{t-1} + \varepsilon_t$, $\varepsilon_t \sim N(0, \sigma^2)$

[6] In this paper, the expected income is an expectation of future income, and the variance of expected income is people's assessment of future income volatility.

[7] Please refer to the appendix for the probability density distribution map.

Table 1: Forecast Result of Earthquake, Income Status and Household Saving Rate

	Income y_0	Future income		Household saving rate sr_1
		Expectation $E[y_t]$	Variance $Var(y_t)$	
Proposition 1	Decrease	Decrease	Constant	Increase
Inference 1	Increase	Increase	Constant	Decrease
Proposition 2	Constant	Constant	Increase	Increase
Proposition 3	Decrease	Decrease	Increase	Increase
	Increase	Increase	Increase	Uncertain

Inference 1: An increase in expected income will lead to a decrease in the savings rate.

Obviously, income growth prospects will ease an actor's pressure to maintain the current level of consumption, making it unnecessary to save too much in the current phase. If residents in an earthquake-hit region fortunately avoid the disastrous consequences and expect spillover effects from government post-disaster relief, they will feel sanguine about future income and save less.

Proposition 2: An increase in the variance of expected income will cause the savings rate to rise.

The economic explanation of this proposition is straightforward: Poor social safety net in a disaster-hit region means higher income uncertainty for local residents, and causes more disturbance to an actor's future income, as manifested in the variance of his expected income. The actor will save more to cope with the potential adverse impact of income volatility.

Proposition 3: Savings rate will rise when expected income declines and its variance increases. When expected income and its variance both increase, change in savings rate cannot be determined.

The joint effect of changes in expected income and its variance: Obviously, the savings rate will naturally rise when expected income declines and its variance grows. This implies that when disaster-hit residents experience physical loss and feel pessimistic about future income, they should also cope with more income volatility, which makes more saving inevitable. When expected income and its variance both increase, an actor still needs to face more future income volatility, and weigh the impact on savings rate from two opposing aspects. At this moment, the final direction of variation is uncertain. By solving the theoretical model and considering actual conditions, this paper forecasts the possible result of the change in household savings rate under different income conditions after the earthquake, as shown in Table 1.

4. Empirical Analysis

With the theoretical path of precautionary saving as the starting point of empirical test and the Wenchuan earthquake of 2008 as an example, we employ China's provincial and household savings rate data to test the explanatory power of the precautionary saving theory under China's specific scenarios. On the temporal dimension, this paper's empirical study regards the period before 2008 as the pre-earthquake and after 2008 as the post-earthquake which corresponds to years of different income changes. Regarding income characteristics, it is hard to find a proxy variable of expected income in the real world. Yet in specifying the income function, this paper defines a close correlation between the expected and current income. Hence, we only need to look for y_0's proxy variable. In our empirical analysis, the change in current income corresponds to this parameter. In specifying the benchmark, the empirical section of this paper should identify similar non-affected households as a control group, so that different household income levels y_0 may serve as a different benchmark for investigating the change in the household saving ratio. Lastly, with the household data series, we may create the variance of post-earthquake income as a proxy variable as the variance of expected income in the theoretical model.

4.1 Empirical Strategy and Modeling

As shown in Figure 3, this paper's empirical analysis comprises two parts, and the first part is a direct test conducted with household data. It is "common knowledge" that the variance of expected income will increase after the earthquake. By calculating the variance of post-earthquake household income, we utilize a systematic GMM method to estimate how the variance of expected income had influenced the household savings rate. Then, we utilize the PSM-DID method to analyze the income effect of the Wenchuan earthquake for households in Sichuan, and thus obtain changes in expected income that cannot be observed in reality. Lastly, we continue to use the PSM-DID method to investigate the final effect of the earthquake on the savings rate of households in Sichuan. After the three test steps, we match research results with a theoretical forecast to establish the path through which "an earthquake influences household savings rate through effects on expected income and the variance of expected income."

The second part is an indirect test of social protection conducted with provincial data. It remains difficult to measure the variance of expected income. Yet a higher level of social protection in a region means a smaller variance of household expected income. We employ the instrumental variable method to empirically determine the correlation between social security spending and household savings rate. Then, we use the synthetic control method to compare differences in the savings rate effects of the Wenchuan earthquake for disaster-hit households, and uncover whether the earthquake's household savings rate

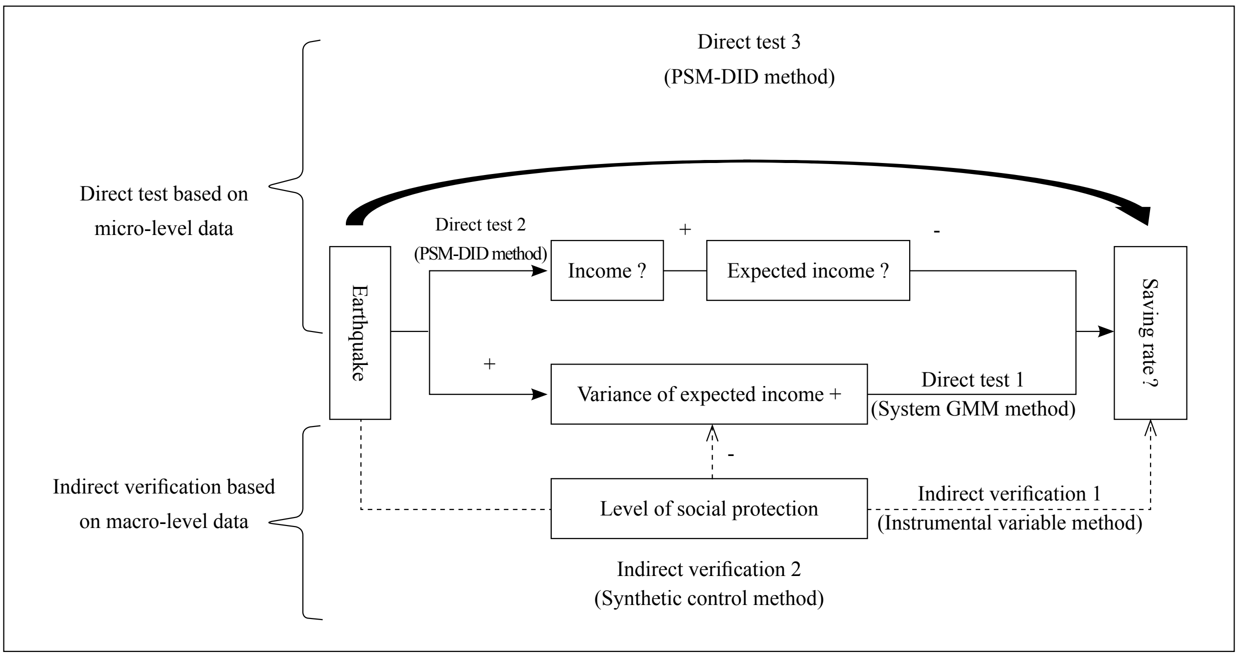

Figure 3: Illustration of Empirical Strategy and Method

effect is subject to the variance of expected income. Through micro-level test and macro-level analysis, we intend to unravel whether precautionary saving may explain actual changes in the savings rate of earthquake-hit households in Sichuan.

4.1.1 Propensity score matching (PSM) – the difference in differences (DID) method

Heckman *et al*. (1997) first developed the PSM-DID method. Compared with the traditional DID method, the PSM-DID method better satisfies the common trend hypothesis and reduces omitted variable error. The first step of the PSM-DID method is to obtain a control group through propensity score matching (PSM). In the direct test section, we use the kernel matching method to conduct a probability estimation with the Logit regression model to obtain the propensity scores of all non-affected household samples, which are then substituted into the Epanechnikov kernel function to match with the treatment group. Finally, we obtain the treatment group and control group estimated with the DID method in the next stage. Equation (3) shows the DID model specification:

$$Y = w_0 + w_1 \times d + w_2 \times Year^{earth} + w_3 \times d \times Year^{earth} + w_4 \times \boldsymbol{\Omega} + \varepsilon \quad (3)$$

Explained variable Y refers to China's household income and savings rate. d is the treatment variable of the earthquake. If a household is located in the epicenter province Sichuan, d is 1; otherwise, it is 0[8]. $Year^{earth}$ is the dummy variable of time: 0 denotes the pre-2008 period, and 1 denotes the post-2008 period. Coefficient w_3 of the interaction term between the treatment variable and the time variable is the average treatment effect of household income and savings rate to be estimated in this paper. Ω is the vector of the control variable, including three characteristic variables of household head, household and region. w_0 is a constant term, and ε is a residual term.

4.1.2 Synthetic control method

With its strong hypothesis on and requirements for data and common trend, the synthetic control method cannot be properly applied to social science topics that occur at the overall level (country, region, city, etc.) and influence a few general entities. The question is how to treat the estimated effects with macro data from macro indirect evidence? Abadie and Gardeazabal's (2003) synthetic control method offers a technical approach to solving this dilemma. Compared with the DID method, the synthetic control method compares entity combinations, and its weighted average method ensures data transparency. Besides, this method usually requires no post-event group, more relaxed time trends, and a smaller sample size. For these advantages, we employ the synthetic control method to test the earthquake's impact on household income and savings rate in Sichuan with provincial-level data.

$$\begin{aligned} Y_{it} &= Y_{it}^{N} + \alpha_{it} D_{it} \\ \alpha_{it} &= Y_{it}^{I} - Y_{it}^{N} \end{aligned} \quad (4)$$

We assume that the total number of provinces is J+1, that only province 1 had experienced the earthquake's impact at time t_0, and that other non-affected J provinces may serve as the counterfactual control group for province 1. In equation (4), Y_{it} means household income and savings rate of province i at time t . Y_{it}^{N} is household income and savings rate in province i experiencing no earthquake at time t. Y_{it}^{I} is household income and savings rate in province i when experiencing the earthquake at time t. D_{it} means whether province i had experienced the earthquake at time t, and is a binary treatment variable.

[8] In conducting an empirical test at the macro level, this paper has excluded five provinces which had already experienced earthquakes above Richter magnitude scale 6.0: Yunnan (2003; 2007, Dayao, Pu'er County), Tibet (2003; 2004; 2005; 2007; the boundary between Ritu and Gaize, Bange, Zhongba, Longge'er), Qinghai (2003; 2004, Delingha, the boundary with Tibet), Xinjiang (2003; 2005, Jiashi, Wushi), Jilin (2002, Wangqing).

α_{it} is the treatment effect of province i when experiencing the earthquake at time t. Further referencing Abadie and Imbens's (2010) technical method and data-driven approach, we define 26 regional characteristic variables such as GDP and CPI as synthetic control variables to estimate the weight m_j of each province in the control group, to artificially create a synthetic control province that is the most similar to the province in the treatment group. Then, we obtain the treatment effect of the earthquake for household income and savings rate in province 1 at time t_0, as shown in equation (5).

$$\tilde{\alpha}_{1t_0} = Y_{1t_0} - \sum_{J=2}^{J+1} m_j^* Y_{jt} \tag{5}$$

4.2 Data and Variables

Regarding data source, this paper employs the inter-provincial annual household per capita disposable income and consumer spending data from the Chinese Household Income Project Survey (CHIP) and the National Bureau of Statistics (NBS).[9] In this paper, we reference Bargain *et al.* (2012) for calculating household savings rate "(current-year income - spending) / current-year income" to measure the change in saving stock over time. In selecting the control variables in the micro-econometric test, we try to cover all observable factors which may influence the household savings rate at the three levels of household head, household and region. In a region, public services and social protection may have a substitutive relationship with the household savings rate. Hence, we control for public welfare spending, social security spending and public service spending as a share in total fiscal spending by including

Table 2: Variables Involved in This Paper's Empirical Analysis

Micro-econometric variables		Macro-empirical variables	
Explained variable	Saving rate	Explained variable	Saving rate
Earthquake variable	Time variable, treatment variable	Explanatory variable	Per capita GDP, annual CPI, frequency of geological disasters, per capita disposable income, urban unemployment rate, permanent population at year-end, per capita road area, fertility / mortality rate, direct economic loss from the earthquake*, urban fixed-asset investment*, value-added of primary, secondary and tertiary industries*, value-added of financial industry*, overall property losses from traffic accidents*, cumulative balance of basic pension insurance*, general fiscal budget income and spending*, number of college students△, number of marriage registrations, number of insurance participants△, number of healthcare institutions△, number of foreign-invested health institutions, number of domestic patent inventions△, spending on public welfare, social security and public services as a share of total fiscal spending.
Characteristic variables of the household head	Gender, seniority among siblings, marital status, length of education, household registration (urban or rural), ethnicity, employment status, whether handicap, financial knowledge and skills		
Characteristic variables of household	Per capita annual income, family size, ranking of per capita income in the province (samples)		
Characteristic variables of region	Per capita GDP, the ratio of fiscal spending on public welfare, and the ratio of fiscal spending on public services		

Note: Variables marked with * (divided by regional annual GDP) and variables marked with △ (divided by the regional permanent population at year-end) are both standardized.
Source: CHIP database and the NBS website.

[9] Inter-provincial annual household income and consumption data released by the NBS are obtained from the mean values of CHIP data at the micro level. A good match between macro and microdata has greatly increased the comparability of econometric results at the two levels.

them into regional characteristic variables. More covariates in synthetic control will make it easier to construct a province which is the most similar to Sichuan. For this purpose, this paper tries to identify such a province from multiple dimensions, including economic fundamentals, the level of innovation and openness, the level of basic public services, and uncertainty. Table 2 shows all variables involved in this paper's empirical analysis.

4.3 Direct Evidence from Household Data

According to our hypothesis, an earthquake is followed by an increase in the variance of expected income. Yet so far, no literature has offered any evidence that the variance of expected income may influence households' current-phase consumption and saving behaviors. This paper employs household data to calculate the variance of each household's post-earthquake income, and with consumption and household savings rate as explained variables, employs the systematic GMM method to dynamically estimate how the variance of post-earthquake income is correlated with consumption and household savings rate. As Table 3 shows, consumption will dive if the variance of post-earthquake income increases and income prospect becomes more uncertain. Accordingly, a greater variance of post-earthquake income leads to a significant rise in the household savings rate.

After determining the positive correlation between the variance of expected income and household savings rate, we utilize PSM the DID method to investigate the Wenchuan earthquake's short-term and long-term impacts on household income and savings rate.[10] The Wenchuan earthquake hit the countryside

Table 3: Variance of Expected Income: Effects on Household Savings Rate

	Explained variable: consumption and saving rate	
	Consumption (yuan)	Saving rate (%)
L1. Consumption	0.019 (0.274)	——
L1. Saving rate	——	0.046 (0.422)
Variance	-0.032*** (0.000)	$4.71\times10^{-7**}$ (0.048)
Control variable	Controlled	Controlled
Arellano-Bond AR (1) test	-7.60***	-4.37***
Arellano-Bond AR (2) test	1.2	1.08
Hansen test	17.9	21.84
Difference-in-Hansen test	6.42	7.36
Number of valid households	11285	11285

Note: Numbers in parentheses are P values, *, ** and *** respectively denote significant at 10%, 5% and 1%, the same below.

[10] Sample years for short-term analysis are 2007 and 2008, and those for long-term analysis are 2007 and 2013.

[11] Yao and Xu (2018) uncovers that urban households in Sichuan Province were more vulnerable to the disaster's indirect impact without suffering any significant physical loss.

the hardest, and cities suffered fewer property losses and casualties[11] aside from psychological impacts. We classify total samples into urban and rural samples to discuss changes in household savings rates under more complex income changes after the earthquake. As shown in Table 4, the total sample result reveals that the Wenchuan earthquake had slashed household incomes in Sichuan Province in the short run and led to a sharp rise in the household savings rate. Compared with the basic specification in the theoretical analysis, diminishing post-earthquake income led to falling income prospects and increasing variance of expected income, motivating households to increase precautionary saving for future uncertainties and cut current-phase consumption. The final result is a sharp rise in the savings rate compared with the pre-earthquake period. As the earthquake's destructions fade, "post-traumatic growth" started to generate positive effects, resulting in higher household actual and expected incomes. The effect of rising expected income, i.e. making it less strenuous in the current phase to maintain future living standards, started to appear. Households saw their actual and expected incomes rise compared with the pre-earthquake period. Yet this effect could still be smaller than the opposite effect of increasing variance of expected income, resulting in less consumption and a significantly higher savings rate. These results are consistent with the forecast of Proposition 3.

As can be learned from the result of urban sub-samples, urban households did not suffer direct property losses and casualties. Urban households were geographically better positioned to benefit from post-disaster construction and the "spillover effects" of aid, which allowed them to earn much more income after the earthquake. Despite rising short-term and expected incomes, the variance of post-

Table 4: The Wenchuan Earthquake's Impact on the Income, Spending and Savings Rate of Households in Sichuan (microscopic test) (yuan)

Short-term	Total samples			Cities			Countryside		
	Income	Consumption	Saving rate	Income	Consumption	Saving rate	Income	Consumption	Saving rate
DID result	-14,000***	-20,000***	0.265***	4,900.64**	-11,000***	0.174***	-7,100***	-7,500***	-0.140
	(0.000)	(0.000)	(0.008)	(0.012)	(0.000)	(0.002)	(0.000)	(0.000)	(0.573)
Treatment group	3,061	3,094	3,061	956	956	956	1,826	1,826	1826
Control group	13,581	13,581	13,574	6,546	6,546	6,546	11,027	11,414	10,994
Long-term	Total samples			Cities			Countryside		
	Income	Consumption	Saving rate	Income	Consumption	Saving rate	Income	Consumption	Saving rate
DID result	3,407.09***	-3,400***	0.105***	-3,700**	-3,300***	0.145***	508.878	-873.515*	0.234***
	(0.000)	(0.000)	(0.002)	(0.029)	(0.001)	(0.000)	(0.553)	(0.067)	(0.010)
Treatment group	2,933	2,924	2,925	987	985	987	1,946	1,939	1,938
Control group	26,053	26,004	26,017	10,243	6,716	10,243	15,631	15,595	15,591

earthquake expected income continued to increase. An increase in expected income exerted a negative effect on household savings rate, which was smaller than its positive savings rate effect. As a result, consumption decreased, and household savings rate still increased compared with the pre-earthquake level. This finding is fully consistent with the result of the theoretical forecast. In the long run, the positive income effects of post-disaster reconstruction would fade, and the earthquake's losses would outweigh the long-term positive effects of "post-traumatic growth," thus slashing post-earthquake income.

Less expected income and higher variance of expected income will cause households to consume less and save more. On the contrary, the Wenchuan earthquake had reduced the actual income of disaster-hit rural households in a short period. With less expected income and high variance of expected income, households will cut back on consumption, which theoretically should increase the savings rate. Yet the result of empirical analysis reveals no significant change. Since the direct losses from natural disasters will diminish over time, there is no significant change in long-term household incomes in rural Sichuan compared with the pre-earthquake period. At this moment, the variance of expected income continued to increase, consumption dipped, and household savings rate still rose sharply. Hence, the precautionary saving theory may forecast and explain complex changes in household savings rate under consistent theoretical preconditions and analytical framework both in the short term and long term after the earthquake.

4.4 Indirect Evidence from Inter-provincial Data

The previous section employs household data to test how one of the proxy variables for uncertain income prospects - the variance of expected income - contributes to household savings rate. Yet due to limitations of data structure and technical method, we cannot provide any empirical evidence for the assumption that "an earthquake will be followed by an increase in the variance of expected income." In reality, it is hard to measure the variance of expected income with perfect accuracy. We now try to provide indirect evidence on how precautionary saving contributed to the post-earthquake change in the savings rate of affected households in China. Obviously, better social protection in a region means a smaller variance of expected income for local households. First, we employ uncertain indicators, including the frequency of geological disasters, total property losses from traffic accidents, and unban unemployment rate, as instrumental variables to estimate how social security spending contributes to household savings rate. To ensure robust results, we examine the household savings rate effects of budgetary spending on public welfare and general budgetary spending on public services, which are of the same nature with social security spending,[12] as a share of total fiscal spending. The above instrumental variables may pass the over-identification test and weak instrumental variable test. As can be learned from the three lines of result in Table 5, the percentages of spending on social security, public welfare, and public services all have significantly negative effects on household savings rate. This suggests that in coping with uncertain income prospects, a substitutive relationship exists between household saving and local social security level.

At roughly the same level of income uncertainty, the question is: Will better social protection in a region makes it less necessary for local households to save more and prepare for the worst compared with their counterparts in regions with less social protection? After excluding the five provinces which were hit by geological disasters before 2008 and the treatment group Sichuan Province, we divide 31 provincial-level regions with macro data into three groups ranked by the ascending order of social security budgetary spending as a share of total fiscal budgetary spending. Each group constitutes a

[12] Public welfare spending includes public services, national security, scientific research, education, healthcare, social security and employment, energy conservation, environmental protection, among others.

Table 5: Household Saving Rate Effects of Spending on Social Security, Public Welfare and Public Services (%)

Explained variable: saving rate	*Social security spending*	*Public welfare spending*	*Spending on general public services*
Spending on social protection as a share of total fiscal spending	-0.312* (0.062)	——	——
Spending on public welfare as a share of total fiscal spending	——	-0.445*** (0.001)	——
Spending on general public services as a share of total fiscal spending	——	——	-0.244*** (0.001)
Control variable	Controlled	Controlled	Controlled
Over-identification test	34.490	26.241	26.866***
(Sargan statistics)	(0.203)	(0.432)	(0.491)
Weak instrumental variable test (Cragg-Donald Wald F statistic)	23.783	15.260	18.398
R^2	0.80	0.80	0.80

Note: Instrumental variables include the frequency of geological disasters, total property losses from traffic accidents, urban unemployment rate, and numbers of health institutions, marriage registrations, and on-campus college students.

synthetic control pool for three synthetic control tests. Notably, Sichuan Province boasts a higher level of social protection. In groups with smaller proportions of social security spending, Guizhou is the most similar to Sichuan, i.e. 0.536, which chimes with our impression: Compared with municipalities/ provinces like Beijing and Fujian in the pool, Guizhou and Sichuan provinces are adjacent to each other, and share similar customs, dialects, and economic structure. In the medium group, Henan has the highest synthetic weight, i.e. 0.475. The reason is that compared with other provincial-level regions, Henan is similar to Sichuan in terms of the size of the migrant population and social security. Lastly, in the group with a high percentage of social security spending, Hunan is the most similar to Sichuan, with a weight of 0.666. Both provinces are similar in terms of the geographical environment, level of economic development, culture, and food.[13] As shown in Figure 4, we may find that the low group and the medium group demonstrate higher changes than the high group. In other words, change in Sichuan's savings rate relative to other regions with lower levels of social protection was significantly smaller than the results of comparison with medium and high levels of social protection. That is to say, even under the same income uncertainty, a high level of social protection in Sichuan Province led to a significantly smaller increase in the household savings rate. This discovery reaffirms the role of social protection in motivating household consumption and economic restructuring. It also implies that excessive income uncertainty lies at the heart of China's "high savings rate puzzle." Better social protection holds the key

[13] Both Hunan and Sichuan provinces are located in the Yangtze River basin and of temperate monsoon climate, and feature large mountainous regions. In both provinces, local residents prefer spicy food. In addition, Sichuan's provincial capital Chengdu and Hunan's provincial capital Changsha were recognized as the "happiest cities in China" (Xinhua news agency, People.com.cn, and general socio-economic survey). Both Henan and Sichuan are the most populous Chinese provinces with the largest net population outflows (Henan ranks the first, followed by Sichuan), but are relatively short on educational resources.

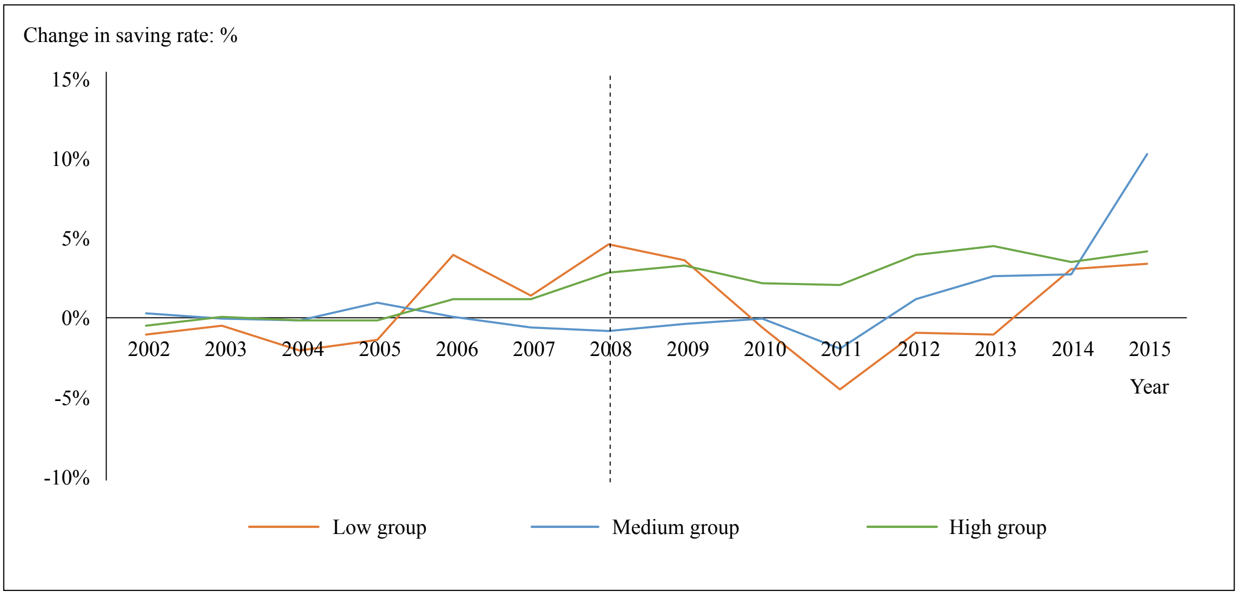

Figure 4: Earthquake's Differentiated Impacts on Household Saving Rate in Sichuan Province under Different Levels of Social Protection

to unleashing China's consumption potentials.

5. Conclusions

Since the late 20th century, Chinese and international academics have yet to agree on the importance of precautionary saving while recognizing the existence of precautionary saving motivation. With different research objects, methodologies and perspectives, existing studies have arrived at disparate conclusions. This lack of academic consensus impedes the development of the precautionary saving theory. In China's unique context, academics have yet to explain China's high household savings rate and its underlying drivers. Hence, this paper combines theoretical analysis with the empirical test, and finds that: (i) With a higher variance of expected income after the Wenchuan earthquake, cities and the countryside recorded higher household savings rates both in the short-term and long-term. Such post-earthquake changes in household savings rate supports the forecast of the precautionary saving theory, and verifies the path where an earthquake influences household savings rate through its effects on expected income and the variance of expected income. (ii) There is a significant relationship of substitution between social protection and household savings rate, which explains that an earthquake's impact on the household savings rate is subject to the variance of expected income.

Indeed, the following three potential problems still exist in our empirical analysis: First, the impact of differences in the data unit. Will the use of micro and macro data lead to different research results? To answer this question, we have employed inter-provincial data and synthetic control methods to estimate the earthquake's treatment effect on household income and savings rate in Sichuan, and reached an identical result with microdata analysis. The second potential problem is the omission of variable error. Neither PSM-DID nor synthetic control method contains all key variables, including time trend and habits, which may influence the household savings rate. In this manner, this paper has added a placebo test to exclude this problem. The final concern is model specification bias. During the sample period of the direct path test, there was no significant change in the survey method and scope of the CHIP database, and an empirical test also considers regional characteristic variables. However, fixed effect control remains likely to be insufficient in the repetitive cross-section data analysis. Referencing Hornbeck and Keniston's (2017) DID model, we have conducted a re-test of results estimated with the PSM-DID method to exclude this problem.

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