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How Prudent are Rural Households in Developing Transition Economies

Evidence from Zhejiang, China

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ABSTRACT

Rural households in developing economies frequently use precautionary saving to cope with income risk. Such prudent behavior can be strengthened in transition economies where more risks are typically faced by households during and after reforms. This paper uses a rich panel of rural households in Zhejiang, China, to examine the correlation between income uncertainty and the target ratio of wealth to permanent income as suggested by the buffer-stock model. The empirical results suggest that Chinese rural households hold a significant level of wealth to mitigate the adverse impacts of income risk. Simulation results show that an increase in income risk leads to a sharp increase in household wealth and precautionary saving could drop substantially if income risk is eliminated. The high level of prudence of rural households under economic transition can help us better understand the developments in China, which will have policy implications for both developing and transition countries.

Keywords: precautionary saving, income risk, buffer-stock model

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1. INTRODUCTION

It is universally observed that rural households in developing countries depend largely on precautionary saving to insure against various income risks (Lim and Townsend 1998; Morduch 2006). These rural households are exposed to a highly risky environment characterized by weather and price volatility, and they are further constrained by limited access to formal credit and insurance markets. However, the welfare loss caused by income risk is not as much as market failures would suggest, due to the adoption of a variety of risk management and coping strategies (Alderman and Paxson 1992; Morduch 1995). Precautionary saving is applied far more frequently than any other ex post coping strategies to smooth consumption. This is because precautionary saving as a self-insurance mechanism does not suffer from adverse selection and moral hazard, as it does with formal credit and insurance markets; or from limited commitment as in informal risk-sharing mechanisms; or from budget constraints, as in public safety nets.

The transition from a centrally planned to a market-driven economy typically introduces more uncertainty to its citizens (Meng 2003). The precautionary saving behavior of its citizens is expected to change when faced with the transition. China's economic reforms since 1978 are believed to have introduced more uncertainty to families. The implementation of the household responsibility system enabled rural households to get out of collectivized communes and become independent units of production and accounting. Free markets expanded and mandatory quotas of crop procurement were largely eliminated. While market institutions play an increasing role in the production and marketing of agricultural products and in labor allocation, rural households are also exposed to a higher level of income risk, compared to the pre-reform period during which risk was pooled within communes and prices were set by the government. An interesting question is whether rural households in China have increased their precautionary savings in response to the perceived rise in risk during the rapid transition.

To address this question, the paper uses a panel data of 427 rural households from Zhejiang province, spanning a long period of 1986–91 and 1995–2006.[1] Zhejiang has emerged as a particularly successful story of economic growth over the past three decades and provides an excellent case for examining the precautionary saving behavior of rural households in the context of rapid transition. Zhejiang is located on the southeast coast of China and is endowed with limited arable lands and natural resources. As presented in Table 1.1, average per capita GDP in Zhejiang grew by 10.2 percent per year from 1984 to 2009, far above the national average growth rate of 8.9 percent. Predominately agriculture-oriented in the early 1980s, it has now transformed into a region well-known for its prosperous private enterprises and specialized manufacturing clusters. The agricultural sector's share of the economy has dropped from 38 percent in 1978 to 5 percent in 2009, while industry has accounted for 52 percent of the economy as of 2009. This growth is widespread as many rural laborers move away from agricultural activities, which quickly increases rural residents' incomes. The net per capita income of rural households reached US$1,465 in 2009, growing at 6.8 percent annually. As a result, per capita rural income in 2009 is more than five times the 1984 level, making Zhejiang the province with the highest per capita rural income in the nation.

We aim to answer two specific questions: Do rural households use precautionary saving to insulate against income risk during the periods of rapid transition? If so, to what extent? Several previous studies have investigated the precautionary saving and consumption smoothing behavior of Chinese households (Kraay 2000; Jalan and Ravallion 2001; Meng 2003; Zhang and Wan 2004; Giles and Yoo 2007). All studies except Jalan and Ravallion (2001) tested earlier predictions of intertemporal consumption theory under risk. They found significant evidence of consumption smoothing by Chinese households. However, as shown in Udry (1995), the existence of consumption smoothing does not necessarily imply the existence of precautionary saving behavior. Our paper makes use of the buffer-stock model that correctly describes the role of precautionary motive in the life cycle consumption path (Carroll

[1] RCRE did not conduct the survey in 1992 and 1994. The questionnaire in 1993 is very different from those of 1991 and 1995. We therefore exclude data in 1993. We use the period 1986-2006 later on to refer to the period of survey used in the paper.

and Samwick 1997; Gourinchas and Parker 2002; Cagetti 2003). Furthermore, our paper differs from the previous literature in several aspects. First, it is focused on the rural reform characterized by the implementation of a contracted household production system. The proxy of income risk is extended to income variability to take account of the decreasing share of agricultural income as well as rural households' diversified and heterogeneous income structure. Second, the calibration of the income process is improved. Since a moving average process exhibits much lower persistence than an autoregressive process even of the same order, the calibration of income process might underestimate the magnitude of income shocks. Instead, the dynamic structure of error terms is modeled as an autoregressive process in this paper, allowing the data itself to determine the orders of the process in estimation. Third, the positive correlation between wealth holdings and income risk was obtained through a quantile regression, ignoring the impact of measurement error under two restrictive assumptions. We expended considerable effort to search for suitable instrument variables both at the household and village levels and to address the attenuation bias caused by measurement error through a method of instrumental variables/Generalized Method of Moments (IV/GMM). We find that rural households in Zhejiang do hold wealth to insulate against income risk. Simulation results show that for rural households at the mean level of wealth, a 1/2 standard deviation increase in income risk leads to a 20.2 percent increase in total net wealth by rural households. Moreover, aggregate wealth drops by 71.7 percent when the income risk of each household is set at the minimum level of income risk in our sample.

Table 1.1—Economic indexes of China and Zhejiang in the post-reform period

	China	Zhejiang
GDP per capita (US $ in 2009)[a]		
1984ft	440	570
2009	3,744	6,490
Annual growth rate (%)	8.9	10.2
Per capita rural income (US $ in 2009)		
1984	218	285
2009	754	1,465
Annual growth rate (%)	5.1	6.8
Share of agriculture in GDP (%)		
1978	28.1	38.1
2009	10.3	5.1
Share of industry in GDP (%)		
1978	47.9	43.2
2009	46.3	51.8
Share of agriculture in total labor force (%)		
1978	62.4	54.9
2009	38.1	17.2
Share of manufacture in total labor force (%)		
1978	20.8	31.7
2009	27.8	46.9
Proportion of urban population (%)		
1978	36.2	48.7
2009	46.6	57.9

Sources: National Bureau of Statistics 2010a, 2010b, 2010c.
Notes: [a] The exchange rate is the year average of 6.831 in 2009 (National Bureau of Statistics2010b).

The rest of the paper is organized as follows. Section 2 describes the theoretical development of intertemporal consumption theory and the buffer-stock model. Section 3 presents the data source and description. Section 4 discusses the empirical models and results. Section 5 provides further discussion on the estimated strength of precautionary saving in the context of existing studies. Policy implications and areas for future research are presented in the last section.

2. THE BUFFER STOCK MODEL: THEORY AND EVIDENCE

Ever since Leland (1968) discovered that the positive third derivative of the utility gives rise to the precautionary motive for saving, uncertainty has been formally incorporated in models of intertemporal consumption optimization. This innovation greatly extends our knowledge of the life-cycle consumption path implied by the certainty equivalence model by decades (Browning and Lusardi 1996). The consumption decision under uncertainty begins with a typical dynamic utility maximization problem:

$$max E_t[\sum_{t=0}^{T} \beta^{-t} u(c_t)] , \tag{1}$$

where E_t is the expectation operator conditional on information available at time t, $u(\cdot)$ is an additively separable contemporary utility function, c_t is the consumption at period t, and $\beta = (1+\delta)$ is a discount factor, $\delta > 0$. The evolution of assets is

$$w_{t+1} = R(w_t - c_t) + y_{t+1} , \tag{2}$$

where w_{t+1} and y_{t+1} are wealth and income at period $t+1$, and $R = (1+r)$ is the gross interest rate. If future income is assumed to be variable but nonstochastic, for any concave utility function, a closed–form solution is

$$C_{CEQ,t} = \left(\frac{r}{1+r}\right)\left[\frac{1}{1-\left(\frac{1}{1+r}\right)^{T-t+1}}\right][w_t + E_t \sum_{j=1}^{T-t}(1+r)^j \cdot y_{t+j}] , \tag{3}$$

where the optimal consumption $C_{CEQ,t}$ is a fixed portion of the sum of current physical wealth and the present discounted value of human wealth. Even if income is stochastic, the solution above is also applicable under two assumptions: $u(\cdot)$ is quadratic, and c_t is allowed to range from $-\infty$ to $+\infty$.

This solution is commonly referred to as the certainty equivalent model, implying that the path of consumption over the life cycle is independent of the path of income. After the life cycle/permanent income hypotheses set up the foundation for modern intertemporal consumption theory, this model takes a lead role in the theoretical field for three decades. However, it fails to sufficiently explain several stylized facts on consumption, one of which is the phenomenon that income tracks consumption closely at both the individual household level and the aggregate level (Carroll and Summers 1991).

An extension of the certainty equivalent model is to allow for flexibility by defining an exogenous stochastic income process as

$$y_t = p_t \varepsilon_t, \tag{4}$$

where p_t is permanent income and ε_t is a multiplicative transitory shock to income. It is assumed that ε_t follows a lognormal distribution with mean $-\frac{\sigma_\varepsilon^2}{2}$ and variance σ_ε^2, that is, $log\varepsilon_t \sim N(-\frac{\sigma_\varepsilon^2}{2}, \sigma_\varepsilon^2)$, and thus $\log E(\varepsilon_t) = 0$, $E(\varepsilon_t) = 1$. A transitory shock affects an income stream in an ad hoc way, and does not improve or impair the realization of the income stream in the long run. The permanent income p_t is often calibrated as a random walk with drift:

$$p_{t+1} = p_t g \varphi_{t+1} , \tag{5}$$

where g is a growth factor, and φ_{t+1} is a permanent shock to income, also assumed to have the same distribution as ε_t, $\log\varphi_t \sim N(-\frac{\sigma_\varphi^2}{2}, \sigma_\varphi^2)$. Unlike transitory shocks, permanent shocks refer to any contingent events that permanently change the path of the income stream.

Based on equations (1), (2), (4), and (5), the optimal consumption path can be obtained by solving the following Bellman equation:

$$\begin{aligned} V_t &= \max_{\{c_t\}}\{u(c_t) + \beta E_t[u_{t+1}(w_{t+1})]\} \\ &= \max_{\{c_t\}}\{u(c_t) + \beta E_t(u_{t+1}[R(w_t - c_t) + p_t g \varphi_{t+1} \varepsilon_{t+1}])\}, \end{aligned} \quad (6)$$

where $V(\cdot)$ is a value function of total expected discounted utility. Its first order condition is the general Euler equation

$$u'(c_t) = R\beta E_t[u'(c_{t+1})] \,. \quad (7)$$

In order to maintain such characteristics as a positive third derivative and decreasing absolute risk aversion, a constant relative risk aversion (CRRA) utility function is applied rather than a quadratic or constant absolute risk aversion utility function. But a closed-form solution could no longer be derived under CRRA, and studies in this area had to confine themselves to testing the implications of the Euler equation. Zeldes (1989) used numerical techniques to calculate an approximation to the optimal consumption path and found a dramatic departure from the certainty equivalence solution. Deaton (1991) imposes an additional assumption,

$$R\beta E[(g\varphi)^{-\rho}] < 1 \,, \quad (8)$$

where ρ is the coefficient of relative risk aversion. This assumption is called the impatience condition. It is substantially weaker than $\delta > r$;, that is, the time discount rate is less than the interest rate. Deaton (1991) shows that the problem defines a contraction mapping one and that the consumption functions defined by the problem converge from any well-behaved initial starting function. Carroll (1997) applies the same assumption as Deaton (1991), named impatience, and also uses numerical technique to prove that expected consumption growth is a function of the ratio of wealth to permanent income, and there exists a target ratio where the expected growth rate of consumption is steady and slightly lower than the growth rate of permanent income. This is known as the buffer-stock model. The model demonstrates that the prudent and impatient consumers have a target wealth-to-permanent-income ratio such that, if wealth is below the target ratio, prudence will exceed their impatience, and the consumers will save. On the other hand, if wealth is already above the target ratio, impatience will exceed prudence, and the consumers will dissave.

Carroll and Samwick (1997), Gourinchas and Parker (2002), and Cagetti (2003) further attempt to disentangle the influence of the precautionary motive from that of the life-cycle motive, as the latter is the predominant motive over a consumer's lifetime under the certainty equivalence model. Their simulations consistently indicate that the precautionary motive largely drives a consumer's behavior for the majority of his working life, while the life-cycle motive regains its leading role near his retirement at 40 to 50 years old. Because the previously used numerical techniques are criticized as a black box, Carroll (2009) proposes the standard method for analyzing dynamic stochastic optimization based on contraction mapping theory. By building a rigorous theoretical foundation for the buffer-stock model he proves the existence of a target level of wealth-to-permanent-income ratio. Carroll and Toche (2010) further prove that an increase in uncertainty results in either an increase in the saving rate or an increase in the target ratio of resources to permanent income, supplying a testable hypothesis for empirically estimating the prudence of a given consumer.

There also exist ample studies on precautionary saving behavior in developing countries. Based on the hypotheses they examined and also an evolving theory of intertemporal consumption under uncertainty, these studies can be categorized in three streams. The precautionary saving studies in the first stream test the hypothesis that rural households deplete in-kind assets after shocks, and they show that households use savings to smooth income fluctuations (see, for example, Rosenzweig and Wolpin 1993; Mogues 2011). However, a few studies in the same stream also find the limited effectiveness of those assets functioning as a buffer (see Fafchamps, Udry, and Czukas 1998; McPeak 2004; Kazianga and Udry 2006; McPeak 2006; Verpoorten 2009). Dercon (2005) offers three possible explanations for the insufficient role of asset accumulation and depletion in self-insurance strategy. In the second stream, the precautionary saving studies respond to Paxson's (1992) innovative work testing the implication of the certainty equivalence model that households consume most of their permanent income but save the entire transitory income (see Meng 2003). Meanwhile, another testing approach, originated from Hall (1978), uses the log-linearized Euler equation to examine the intertemporal consumption theory's caveat that households maintain a constant marginal propensity to consume over time (Zhang and Wan 2004; Giles and Yoo 2007; Lee and Sawada 2010). As Udry (1995) demonstrates, the studies from those two streams only provide support for the existence of consumption smoothing behavior but do not necessarily correspond to the existence of precautionary saving behavior. The studies in the third stream follow the buffer-stock model and reveal the essence of precautionary saving behavior that households save in anticipation of unforeseen risk (Udry 1995) or that an increase in uncertainty results in either an increase in the saving rate or an increase in the target ratio of resources to permanent income (Carroll and Toche 2010). There are several studies that explicitly test these hypotheses with regard to rural households in developing countries, including Udry (1995); Jalan and Ravallion (2001); and Ersado, Alderman, and Alwang (2003).

This paper, compared with Udry (1995) and Ersado, Alderman, and Alwang (2003), expands the measure of income risk from weather volatility to income fluctuations beyond weather events, accounting for rural households' diversified income composition and hence heterogeneous risk profile in the context of rapid growth following economic reform. Similar to Jalan and Ravallion (2001), this paper constructs the proxy of income risk by calibrating rural households' dynamic income process. But rather than imposing a two-order moving average process, we model an autoregressive process and allow the orders of the process to be determined by data in regression. Since a moving average process exhibits much lower persistence than an autoregressive process even of the same orders, their calibration of the income process might underestimate the welfare consequence of income shocks. Furthermore, they estimate the positive correlation between wealth holdings and income risk through a quantile regression and ignore the impact of measurement error under two restrictive assumptions. We attempt to address the attenuation bias caused by measurement error through an IV/GMM strategy, making considerable effort to search for suitable IVs both at the household and village levels.

3. DATA SOURCE AND ITS DESCRIPTION

The data for this study come from the annual national household surveys conducted in rural areas by the Ministry of Agriculture's Research Center for Rural Economy (RCRE). This study uses data from Zhejiang province, covering 10 villages in 1986–91 and 1995–2006. The survey keeps track of households in the sample, unless they move out of the village or no longer have any living members. This allows us to record the evolution of income, consumption, and wealth holdings over a period of rapid economic growth. We selected a balanced panel of 427 households each year and obtained 7,686 observations. There were 331 observations dropped from the sample due to violation of the impatience assumption of the buffer-stock model, including households that had a household head over 60 years old, two or fewer members, and one or fewer working members between 16 and 60 years old. Additional observations were dropped in log transformation, which gives us 7,302 observations for the income equation and 6,934 observations for the wealth ratio equation.

Our analysis uses three sets of explanatory variables presented in empirical models initiated by Carroll and Samwick (1997): household characteristics, income, and wealth. Household characteristics include household size, age, and education of the head, and social connection dummies (that is, whether a household is Wu Bao Hu[2], whether a household has member in army, civil servant, Communist Party member, or cadre). Several variables are used to express human capital: number of laborers, highest education of nonhead laborers, number of laborers with skills, and number of laborers with training. Household land endowment includes areas of cultivated land and areas of land for horticulture, forestry, and ponds. Household income structure is described by four variables: number of income sources, primary and secondary income sources, and principal industry of on-farm business. The definitions and statistical descriptions of these key variables are reported in Tables 3.1 and 3.2, grouped into continuous and categorical variables. The expected signs of these variables for the econometric model are also listed based on economic theory and literature.

[2] Wu Bao Hu households include the elderly, the disabled, or minors in rural areas who are without the capacity to work, any alternative source of income, or obligors to support them. The government provides Wu Bao Hu with food, clothes, medical care, housing, funeral service, and education from government.

Table 3.1—Definition and descriptive statistics for continuous variables

Variable	Definition	Mean	SD	Min	Max	Expected Sign: Income Equation	Expected Sign: Wealth Equation
income	total net income (US $ in 2009)[a]	3,740	8,641	-9,810	228,940	/	/
wealth	total net wealth (US $ in 2009)[a]	13,953	39,252	-78,245	1,193,720	/	/
age[b]	age of the head	44.91	11.51	6	89	inverse U	inverse U
hhsize	household size	3.77	1.31	1	11	inverse U	inverse U
labor	number of laborers whose age is between 16 and 60	2.63	1.16	0	8	+	/
educ	education of the head, 1=being at school less than 6 years, 2=6~9 years, 3=9~12 years, 4=12~16 years, 5=more than 16 years	2.20	0.83	1	4	+	/
educ_high	the highest education of nonhead household laborers, the same definition as education of the head for its values between 1 and 6, and 0 indicates no labor in this household	2.71	0.88	0	5	+	/
labor_skill	number of laborers with skills	0.26	0.55	0	6	+	/
labor_training	number of laborers with training	0.28	0.57	0	4	+	/
land_cul	acreage of cultivated lands (acres)	0.33	0.42	0	11.66	+	/
land_hor	acreage of horticultural lands (acres)	0.17	0.35	0	3.95	+	/
land_for	acreage of forest lands (acres)	0.95	2.99	0	87.31	+	/
land_pon	acreage of ponds (acres)	0.16	0.87	0	14.50	+	/
growthrate	growth rate of total net income	0.51	17.01	-816	1106	+	+/-
source	number of income sources	2.76	0.98	1	6	+	+/-

Source: Authors' compilation based on survey data.
Notes: [a] The exchange rate is the year average of 6.831(National Bureau of Statistics 2010b).
[b] The questionnaire during 1986–91 did not inquire age of the head, and the dataset during 1995–2002 reported the index of age sometimes for the head, but sometimes for main labor. We had to calculate the age of the head backward from 2003, when personal characteristics for each household member were available. This approach fails to account for the households whose heads were replaced between 1986 and 2002.

Table 3.2—Definition and descriptive statistics for categorical variables

Variable	Definition	Percent	Expected sign: Income equation	Expected sign: Wealth equation
guarantees	whether being granted with a social welfare of five guarantees due to poverty	0.31	-	+
martyred	with a member being enrolled in army	1.50	+	+/-
civilservant	with a member being a staff in an administrative institution in the township and above	2.71	+/-	+/-
cadre	with a member being a village cadre	5.66	+	+
partymember	with a member being a party member	13.95	+	+
Primary and secondary income sources[a]				
agri	income from agricultural on-farm business, including cultivation, forestry, husbandry and fishery	27.80 (29.68)	- (-)	- (+/-)
nonagri	income from nonagricultural on-farm business, including manufacture, construction, transportation, commerce, catering and service	25.93 (14.47)	+ (+)	+ (+/-)
off-farm	income from off-farm investment, including managing enterprises and merchandising out of town	7.69 (5.23)	+ (+)	+ (+/-)
wage	wage earned from local and migrant labor work [MEASURE?]	21.09 (19.16)	+ (/)	+/- (+/-)
collective	Income from the collective, referring to wage work for collective-owned enterprises as well as dividend as their investment in these firms	13.83 (11.38)	_ (-)	- (+/-)
property	property income, including rent, interest, stock dividend and bonus	2.12 (9.46)	+/- (+)	+ (+/-)
salary	income from being a cadre and teacher in village, as well as staff in an administrative institution in the township and above	1.54 (1.37)	- (+/-)	- (+/-)
nosec	no secondary income	- (9.25)	- (+)	+ (+/-)
Main industry of on-farm business				
cultivation	Cultivation	30.37	-	-
forestry	Forestry	5.09	+/-	+
husbandry	Husbandry	7.91	+/-	-
fishery	Fishery	11.32	+/-	+
manufacture	Manufacture	9.28	+	+
construction	Construction	0.70	+/-	+
transportation	transportation	6.74	+	+
commerce	commerce, catering and service	12.05	+	+
othindustry	other industries	4.68	+/-	+/-
none	None	11.87	-	+

Source: Authors' compilation based on survey data.

Notes: [a]. Since the primary and secondary income sources share most of the categorized items, we report the descriptive statistics on these items for the two types of income sources simultaneously, and present the percentage for the secondary income source in brackets.

Income is calculated as the sum of total net income, including the returns to endowments before taxes to account for income shocks, covering the profits of agricultural and nonagricultural on-farm business (including in-kind income), property income, income from the collective,[3] labor work and off-farm investment, and salary as civil servants. As presented in Table 3.3, rural households in Zhejiang derived their income mainly from on-farm agriculture (29 percent), nonagricultural on-farm business (23 percent), labor work (22 percent), and income from the collective (14 percent).

Table 3.3—Income structure and variability by income sources for rural households in Zhejiang, 1986–2006

	Income Structure (%)		Coefficient of Variation			
	Mean	SD	Obs	Mean	Median	SD
Total net income	100.0	-	427	0.51	0.47	0.23
On-farm business	52.5	64.0	427	0.86	0.73	0.77
Agriculture	29.1	63.2	424	0.86	0.76	1.30
Cultivation	14.6	21.3	423	0.80	0.69	0.46
Forestry	3.3	11.9	160	1.81	1.73	2.49
Husbandry	5.5	21.4	397	3.62	1.45	63.22
Fishery	5.7	56.4	181	1.58	2.50	7.93
Nonagriculture	23.4	66.1	406	1.69	1.34	1.45
Manufacturing	6.4	26.4	220	1.85	2.28	3.76
Construction	0.6	6.6	52	3.12	4.01	1.94
Transportation	4.2	31.0	164	3.43	2.45	16.03
Trade and service	8.9	28.6	301	2.34	2.36	7.14
Off-farm investment	7.0	20.8	305	2.64	2.52	1.06
Wage	21.5	47.6	417	1.48	1.29	0.80
Income from the collective	13.5	28.9	407	1.88	1.72	0.79
Salary	1.6	11.9	92	13.30	1.30	28.39
Property income	3.9	32.2	348	2.21	2.05	1.12

Source: Authors' compilation based on survey data.
Notes: Based on the balanced panel of 427 rural households. Observations of coefficient of variation refer to the number of sample households of nonzero income for at least one year over the whole survey period.

The riskiness associated with various income sources is measured with coefficients of variation (CV) after eliminating their time trends (the right side of Table 3.3). For rural households in Zhejiang during 1986–2006, CV of total net income is lower than any of its components, indicating that income diversification is an effective way to mitigate income risks for rural households. Ranked by the riskiness of income sources according to their median CV, agricultural on-farm business is the least risky, followed by labor work, salary, nonagricultural on-farm business, and income from the collective. Property income and off-farm investment are the most volatile incomes with high CV values. Meanwhile, contrary to the riskiness of economic activities offered by traditional development literature, agricultural on-farm business, especially cultivation, is found to be the least volatile source of rural household income.

[3] Income from the collective decreased sharply and became a form of welfare granted by the collective of a village as collective-owned enterprises went bankrupt, were sold, or were transformed into private companies in the late 1990s. We include income from the collective in the measure of total net income to account for its importance in the early phase of the post-reform period, when township and village enterprises emerged as important forces in China's rural industrialization. As mentioned in Section 3, we calculate the measure of total net income as returns to endowments. When income from the collective turns into a form of welfare, the inclusion of this type of income in total net income will not induce bias due to its small share in net income.

Our measure of wealth is total net worth, including savings plus the stocks of consumer durables, houses, and productive capital assets, minus formal and informal loans. The illiquid durable asset is included in the calculation because it is a vital component of household wealth, and rural households can liquidate them to cope with emergencies even at high transaction costs. We depreciate the expenditures on these durable goods following Benjamin, Brandt, and Giles (2005), which assumes that consumer durables and productive capital assets have a useful life of 7 years and houses a life of 20 years.

4. EMPIRICAL MODELS AND RESULTS

There are four standard approaches to estimating the strength of precautionary saving: the Euler equation, survey evidence, structural estimation, and regression evidence (Carroll and Kimball 2008). The Euler equation exactly reflects the intertemporal consumption theory's caveat that consumers attempt to keep marginal propensity to consume constant over time. Some of the very first applications of this method to agricultural economics are seen in Chen (1995) and Chen, Meilke, and Turvey (1999). The empirical studies of precautionary saving could only test its log-linearized approximation with a first or second order Taylor expansion. The ignored terms of higher order are proven to be endogenous, and they can take any values to ensure that the growth rate of consumption equals the growth rate of income. This endogeneity makes it impossible to use the approach of the Euler equation to uncover structural parameters such as the coefficient of relative risk aversion (Carroll 2001). The survey evidence approach directly questions consumers about their optimal level of precautionary wealth and then correlates it to observable household characteristics. Since it relies on a specially designed questionnaire, the survey evidence approach could only serve as a reference for other methods, restricting its application (see, for example, Kennickell and Lusardi 2004). The approach of structural estimation calibrates a dynamic stochastic optimization using income shocks extracted from household surveys. The regression evidence approach tests the central implication of the Buffer-Stock model by estimating a reduced-form equation of the ratio of wealth to permanent income, which indicates that increased uncertainty leads to an increased wealth ratio. These two approaches are parallel in empirical studies with their own methodological foundations. Compared to structural estimation, reduced-form regression allows the data to speak in a much less filtered way (Carroll and Kimball 2008) and is adopted for this study.

To estimate how prudent rural households are, our econometric model includes two steps. First we calibrate a dynamic income process to construct permanent income and income risk measured by income variability. In the second step, we examine the determinants of the wealth ratio to test the positive association between wealth holdings and income risk, as proposed by Carroll and Samwick (1997).

Calibration of the Income Process

The measures of income risk applied in empirical studies include income variability, equivalent precautionary premium, subjective probability of income growth, subjective and real probability of job loss, and the occupation of a civil servant. Rainfall variance is often used in development economics literature to reflect the risk of agricultural production.

In the structural model of dynamic optimization presented in Section 2, income risk is introduced by calibrating the time-series properties of the exogenous income process, represented as permanent and transitory income shocks and in equations (4) and (5). For parsimoniousness, we do not decompose income shocks into permanent and transitory components. Instead, income risk is measured by the variance of the residuals obtained from the calibration of the income process, named income variability, for each household over the whole survey period.

We adopt income variability to measure income risk of rural households for several reasons. First, the procedure of generating income variability also reveals the income dynamics of rural households and thus the persistence of shocks, which gives the time lags of the shocks' welfare impacts. Second, compared to two indexes of subjective probability, the calculation of income variability only depends on the data of income and household characteristics other than those that are provided by a specially designed questionnaire, and thus this measure of income risk can be utilized in existing household surveys. Third, income variability covers the causes of income fluctuations beyond the probability of job loss, and it includes illness, unemployment, and macroeconomic instability. Four, rather than depending on any single income source, income variability captures income diversification by covering multiple income sources of rural households. Lastly, income variability is not limited by the weakness of rainfall variance when agriculture is no longer the dominating activity for the livelihood of rural households, as in the case of rapidly changing economies. Guiso, Jappelli, and Terlizzese (1992) criticize income variability as a poor measure of income risk for urban households, citing its risk of containing variable but controllable components of income. The inaccuracy of income variability is less a problem for rural households since the income of rural households tends to be more volatile than that of urban households, thus it is a minor concern in the study of precautionary saving for rural households.

There are two ways to calibrate a dynamic income process.[4] One is to use a dynamic model, which takes lagged dependent variables as independent variables; the other is to use an error component model defined by the dynamic structure of error terms. We adopt the error component model, following the practice in labor economics of studying wage inequality by calibrating a labor income process (see, for example, Guvenen 2007). The parsimonious form of the error component model decomposes log income into four parts: a common growing part, measured by a constant to reflect the growth of aggregate productivity; an idiosyncratic growing part, measured by fixed effects and explained by household features; a residual term evolving according to the autoregression of order one; and the residual's innovations (Guvenen 2009). Rather than the moving average process (Carroll and Samwick 1997; Jalan and Ravallion 2001), this paper focuses on an autoregressive process, because it exhibits a higher persistence than a moving average process of the same order, and thus it is able to capture the persistent welfare effects of income shocks more accurately.

We modify the baseline error component model to be a one-level mixed-effect linear model for the household panel

$$
\begin{aligned}
y_{it} &= X_{it}\beta + u_i + \varepsilon_{it}, \qquad (9)\\
u_i &= a_{0i} + a_{1i} edu\_high_{it},\\
\varepsilon_{it} &= \sum_{d=1}^{D} \psi_d \varepsilon_{i.t-d} + \eta_{it,}
\end{aligned}
$$

where y_{it} is the log of the total net income of rural household i in year t. X_{it} is a vector of household characteristics, human capital, land endowment, social connections, income structure, and dummies for villages and survey years. u_i are household-specific unobservable random effects. In u_i, we allow a random intercept a_{0i} and a random slope a_{1i} on edu_high_{it}-—the highest education of all nonhead household laborers—to account for the fact that some family members who receive better education become principal decision makers in the household and may even replace the role of the head of the household. The orders of the autoregression for error term ε_{it} will be determined by the regression, and innovation η_{it} is assumed to be white noise.

The estimated results of the income regression are reported in Table 4.1. Log total net income of rural households can be explained by an autoregression of order four, with coefficients of 0.430, 0.110, 0.111, and 0.062, respectively. The persistence in the errors of the income process implies that an income shock in the current year will affect rural households' behavioral response for the next four years. A simple simulation indicates that the effect of an income shock will attenuate to 43.0, 26.5, and 9.8 percent of its original magnitude after 1, 5, and 10 years. However, the sharp decrease in autoregression coefficients suggests that the persistence is much weaker than a random walk. Our results are similar to the findings of Jalan and Ravallion (2005) in China. They find that income can recover by 54.5 percent in the first year after a shock, based on a dynamic model with a one year lag in the dependent variable.

[4] Almost all of the existing literature's evidence on income dynamics relates to the labor income of urban households, and is based on the theory of human capital. The calibration of rural household's income requires the use of total net income, and lacks any such theoretical foundation. Hence, we apply the same income calibration method for urban households to calibrate the income process of rural households.

Table 4.1—Estimation results of the income equation, dependent variable = log (total net income)

Variable	Coefficient	S.E.
age	0.009*	.005
cubic age (×10^{-6})	-2.360***	.692
hhsize	0.468***	.027
squared hhsize	-0.037***	.003
Labor	0.117***	.012
Educ	0.045***	.014
educ_high	0.089***	.018
labor_skill	0.048***	.018
labor_training	0.033*	.018
land_cul	0.017***	.004
land_hor	0.009	.007
land_for	0.001	.001
land_pon	0.005**	.002
fiveguarentees	-0.290**	.132
Martyred	0.081	.068
civilservant	0.060	.062
Cadre	0.089**	.044
partymember	0.181***	.033
growthrate	0.003***	.000
Source	0.040***	.010
Primary income source (base = wage)		
Agri	-0.107***	.031
nonagri	-0.023	.033
off-farm	0.074**	.031
Collective	-0.008	.030
Property	-0.314***	.059
Salary	-0.023	.069
Secondary income source (base = no secondary income)		
Agri	0.089**	.034
nonagri	0.021	.037
off farm	0.196***	.042
Wage	0.157***	.034
Collective	0.151***	.036
Property	0.119***	.037
Salary	0.286***	.068
Main industry of on-farm business (base = cultivation)		
Forestry	0.265***	.044
Husbandry	0.079**	.028
Fishery	0.146***	.040
Manufacture	0.383***	.039
Construction	0.128	.091
Transportation	0.389***	.043
Commerce	0.360***	.037
Othindustry	0.036	.039
None	0.039	.036
Constant	4.997***	.166
Random-effects parameters		
educ_high	-1.568***	.078
Constant	-0.489***	.085
Correlation	-10.580	2532.387
Residuals: AR(4)		
phi1	0.430***	.014
phi2	0.110***	.015
phi3	0.111***	.017
phi4	0.062***	.016
Log residuals	-0.437***	.014
Observations	7302	

Source: Authors' estimations.

Notes: *,**, and *** indicate significance at the 10, 5, and 1 percent levels, respectively.

For household characteristics, total net income is correlated with age of the head of household and household size, both of which exhibit an inverse U shape, reflecting their life-cycle feature. Households with more laborers and higher education levels earn more net income. As hypothesized in human capital theory, education of the head of household, number of laborers with skills and training, and the highest education level of nonhead household laborers all result in higher total income, with the last variable contributing the most. Other household characteristics are of the expected sign as summarized in Tables 3.1 and 3.2. Areas of cultivated land and ponds are significantly and positively correlated with total income. The households with five-guarantee status are generally low-income families, while the households with better social connections (with a member being a cadre or party member) earn significantly more than an average rural household. Higher income households report strong income growth and multiple income sources. Compared to the base group, which relies on labor work as the primary source of income, the groups depending on agricultural on-farm business and property income generate significantly less total net income, but the households depending on off-farm investment earn more. The rural households that rely on a secondary source of income other than nonagricultural self-employment obtain significantly more income than those who derive income exclusively from a single source. Compared with cultivation, other primary sources of income among on-farm industries produce more income per household, such as (in order of profitability) transportation, manufacture, commerce, catering and service, forestry, fishery, and husbandry.

Estimation of Wealth Ratio Equation

With income variability measuring risks and permanent income measuring the long-term capacity of generating income, we test the positive correlation between wealth holdings and income fluctuations implied by the buffer-stock model (Carroll and Toche 2010). Following Guiso, Jappelli, and Terlizzese (1992), the wealth ratio equation is specified as

$$\ln\left(\frac{w_{it}}{y_i^P}\right) = \alpha_0 + \alpha_1 \ln\left(y_i^P\right) + \alpha_2 ln(v_i) + M_{it}\beta + \varepsilon_{it}\ , \tag{10}$$

where w_{it} is total net wealth of the rural household i in year t, y_i^P and v_i are household i's time-invariant permanent income and income variability during the entire sample period, M_{it} includes household demographics to control life-cycle wealth accumulation, as well as the variables describing social connection and income structure to proxy risk preference. The hypothesis of the positive association between wealth holdings and income risk implies $\alpha_2 > 0$.

The variable for household income inevitably contains some measurement error. The measurement error introduced into income variability in the income calibrating process will affect the estimated coefficient of income variability in the wealth ratio equation unless either of two assumptions holds: the measurement error is individual-specific, time invariant, and uncorrelated with other regressors, or it is independent and identically distributed (Jalan and Ravallion 2001). However, these assumptions are rarely satisfied. If the errors are heteroskedastic across households and time variant, attenuation bias in the relevant estimates arises. The standard solution to the errors-in-variables problems is to estimate the wealth ratio equation using instrumental variables (IVs).

In studies on urban households' precautionary saving behavior, the IV strategy has been identified as one of the difficult problems in estimating the strength of precautionary saving (Carroll, Dynan, and Krane 2003). The first proposed set of IV in literature are occupation, industry, education, and their interactions with demographic variables, as they are able to reflect different lifetime profiles of income and uncertainty for different occupations and educational groups (Carroll and Samwick 1997, 1998). However, this set of IV are suspected to be correlated with wealth accumulation and thus give rise to the problem of self-selection, because more risk-averse consumers might both hold more precautionary wealth and choose occupations with lower job-loss risk (Carroll, Dynan, and Krane 2003).[5] The subsequent studies are inclined to use them as proxies of risk preference, and select exogenous variables as IV, such as the regional rate of unemployment and the regional dummy (Lusardi 1997). In the literature of development economics, since the majority of studies use exogenous weather events to measure income risk for rural households, an IV strategy is not needed in the analysis.

Our estimation strategy is the following. First, we estimate the wealth ratio equation in the framework of GMM, which is robust to heteroskedasticity and serial correlation. Then, we use variables of social connection and income structure to proxy rural households' risk preference, resembling the practice of using occupation to proxy urban households' risk preference (for example, in Carroll, Dynan, and Krane 2003). At last, with little guidance offered by previous studies on rural households, we select IV at the household and village levels, respectively. We have also tried to find a set of IV composed of both household- and village-level variables, but none of them can pass the underidentification test of the Kleibergen-Paap Lagrange Multiplier statistic and the overidentification test of the Hansen J statistic.

At the household level, we choose a set of IVs composed of the growth rate of income and four human capital variables—education level of household head, the highest education level of all nonhead household laborers, number of laborers with skills, and number of laborers with training. Because of the positive correlation between income growth and variability, the growth rate of income can be used to reflect income fluctuations without involving income structure directly. Human capital variables show a household's capacity to adopt new technology and assume risk.

At the village level, we choose a set of IVs describing a village's income structure: primary and secondary income sources, principal industry of on-farm business, and main industry to which laborers are allocated. Since village information is not readily available, these village-level variables are derived from household-level data in our balanced panel for each village. Furthermore, we build the four indexes of village income structure in two ways. Taking the primary income source, for example, the first way is to aggregate income from each income source in a certain village, then to select the one with the highest level as the primary income source for this village. The second approach is to select the primary income source for each rural household in a village, and then pick the one chosen by most of the households. The former method accounts for the high-return income source, which contributes the most to a village's net income and is the one usually taken by rich households. The latter approach accounts for the profitable income source with relatively low entry barriers and thus is the one available to most households. We calculate all of the four indexes using these two methods and obtain eight variables for the set of IVs at the village level.

Estimated results of the wealth ratio equation are presented in Table 4.2.[6] We first report the results of ordinary least square (OLS) and median regressions, which can be reasonably taken as the

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[5] The problem of self-selection is often emphasized in the literature. Fuchs-Schundeln and Schundeln (2005) even attempt to estimate the bias caused by this problem in a natural experiment. We argue, however, that if income structure is treated as exogenous, that is, under the assumption of income exogeneity, the studies on precautionary saving cannot overcome the problem of self-selection. Precautionary saving is an ex-post risk coping mechanism, while the self-selection of income structure (like occupation selection for urban households) is an ex-ante risk management strategy. If researchers are mainly interested in consumption smoothing with precautionary saving, rather than analyzing a simultaneous application of ex-ante and ex-post strategies, it is reasonable to assume the exogeneity of income structure. More specifically, the income risk in this sense is actually income fluctuations after income composition is determined, which is different from the income risks households face when determining their income portfolio.

[6] A problem in estimating the wealth ratio equation deserves some attention that is caused by log transformation on the dependent variable. The deletion of the observations with nonpositive wealth in log transformation might give rise to the problem of sample selection. Although Carroll, Dynan, and Krane's (2003) theoretical structural model demonstrates that it is not against the rule of intertemporal consumption optimization for households to possess negative net worth, how to allow for the observations with nonpositive wealth entering into the estimation of the wealth ratio equation has become a pervasive problem for empirical studies. And it is also a problem for the studies on rural households in estimating the income equation whose income could be negative due to harvest failure, market price fluctuations, and so forth, but not for the studies on urban households whose labor income is always positive. The log transformation is universally adopted because it is able to transform the heavily skewed distribution of wealth approaching the normal distribution, thereby overcoming the impact of outliers to estimated results. Some studies attempt to tackle this problem with the methods other than log transformation. Fuchs-Schundeln

lower limit to the strength of precautionary saving due to attenuation bias caused by measurement error. The estimated coefficients of log income variability $ln(v_i)$ are 0.366 and 0.325 in OLS and median regressions, respectively, both significant at the 1 percent level. And the coefficients of $ln(v_i)$ in IV/GMM with IV selected from household (IV Model 1) and village levels (IV Model 2) are substantially higher at 1.935 and 3.463. The positive estimates of income variability from all the four regressions imply that a 1 percent increase in income variability could increase the wealth-to-permanent-income ratio w_{it}/y_i^P by 0.4, 0.3, 1.9, and 3.5 percent, respectively. The results confirm the hypothesis that rural households possess wealth to mitigate income risk. Furthermore, the estimates from IV Model 1 and IV Model 2 are much higher than those from OLS and median regressions, indicating possible disparities caused by measurement error. We prefer to report the results of IV Model 2 for reasons discussed in detail in the next section.

and Schundeln (2005) use a Tobit model to include zero-wealth observations. Carroll, Dynan, and Krane (2003) apply an inverse hyperbolic sine transformation to allow for all the nonpositive wealth observations. A Tobit model is not applicable in this paper because our data are not composed of any zero-wealth observations. We have tried inverse hyperbolic sine transformation to transform the distribution of the wealth ratio, but the results appear to reverse the correlation between wealth holdings and income risks. Therefore, we resort to log transformation, and leave the problem for future exploration.

Table 4.2—Estimation results of the wealth ratio equation, dependent variable = log (total net wealth/permanent income)

	OLS		Median		IV Model 1		IV Model 2	
Variable	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Lnvariability	0.366***	.092	0.325***	.031	1.935*	1.004	3.463***	1.349
log(permanent income)	-0.527***	.090	-0.546***	.040	-0.387***	.117	-0.162	.210
Age	0.007*	.003	0.006***	.001	0.013***	.004	0.017***	.006
Hhsize	0.156*	.069	0.138***	.031	0.223***	.070	0.129	.122
squared hhsize	-0.012	.007	-0.011***	.003	-0.021***	.008	-0.013	.013
Labor	0.120***	.020	0.109***	.012	0.131***	.019	0.133***	.035
Fiveguarentees	-0.570	.497	-0.095	.206	-0.521	.477	-0.645	.506
Martyred	-0.264	.176	-0.101	.081	-0.292*	.159	-0.255	.242
Civilservant	0.142	.120	0.116*	.070	0.175*	.102	0.136	.176
Cadre	0.160*	.076	0.101**	.048	0.278***	.096	0.263*	.152
Partymember	0.122*	.070	0.131***	.033	0.025	.082	0.044	.134
Source	0.002	.018	0.013	.014	0.028	.024	0.046	.038
Primary income source (base = wage)								
Agri	-0.089	.067	-0.009	.042	-0.078	.062	-0.105	.113
nonagri	0.126*	.070	0.100*	.047	0.049	.078	-0.054	.125
Off farm	0.205**	.066	0.115**	.041	0.049	.112	-0.113	.151
Collective	-0.048	.061	-0.001	.039	-0.106	.065	-0.113	.104
Property	0.566***	.137	0.490***	.081	0.162	.298	-0.160	.433
Salary	-0.013	.127	-0.045	.094	-0.018	.112	0.003	.182
Secondary income source (base = no secondary income)								
Agri	-0.071	.080	-0.029	.049	0.004	.084	0.019	.135
nonagri	0.014	.083	-0.030	.055	0.085	.086	0.069*	.135
off farm	0.116	.091	0.080	.063	0.093	.089	0.072	.156
Wage	0.019	.083	0.019	.053	0.011	.073	-0.013	.125
Collective	0.287**	.090	0.256***	.052	0.217**	.091	0.153	.159
Property	0.028	.129	-0.031	.097	0.094	.138	0.172	.218
Salary	0.002	.081	-0.031	.051	0.084	.089	0.133	.140
Main industry of on-farm business (base = cultivation)								
Forestry	0.213*	.126	0.069	.061	0.252**	.111	0.094	.181
Husbandry	0.175**	.057	0.190***	.038	0.176***	.049	0.147	.081
Fishery	0.077	.097	0.200***	.051	0.043	.079	0.025	.118
Manufacture	0.244**	.093	0.194***	.054	0.212***	.078	0.111	.124
Construction	-0.013	.128	-0.039	.116	-0.021	.153	-0.307	.315
Transportation	0.101	.104	0.095*	.057	0.035	.094	-0.044	.155
Commerce	0.331***	.078	0.261***	.051	0.235*	.091	0.070	.143
Othindustry	0.045	.093	0.100	.059	0.021	.087	-0.055	.136
None	0.265***	.080	0.267***	.045	0.286***	.071	0.227*	.127
Constant	2.759***	.808	3.216***	.332	0.684	1.445	-1.279	2.350
Obs	6934		6934		6934		6934	
Adjusted R^2	0.4655							
Psudo R^2			0.3263					
Centered R^2					0.2851		-0.2457	
Uncentered R^2			-		0.6475		0.3857	
Underidentification test					0.1510		0.9990	
Overidentification test			-		0.6337		0.2196	

Source: Authors' estimations.

Notes: IV Model 1 and IV Model 2 refer to the IV/GMM regression with IV selected from household and village levels, respectively.
*,**, and *** indicate significance levels of 10, 5, and 1 percent, respectively.

Precautionary saving itself is unobservable. The strength of precautionary saving depends not only on the estimated coefficient of the proxy of income risk, but also on the distribution of wealth and income risk across households. To gauge the strength of precautionary saving, simulation is often used in the literature to illustrate the change of wealth holdings in response to a certain change in income risk. For example, Carroll, Dynan, and Krane (2003) compared their results with those of previous studies by examining the percentage change of wealth in response to a 1/2 standard deviation increase in the proxy of income risk for the households at the median level of wealth. Carroll and Samwick (1998) and Hurst et al. (2010) calculated the percentage change of aggregate wealth when income risk for each sample household is set at the 0^{th}, 25^{th}, and 50^{th} percentile of the distribution of the proxy of income risk, respectively. Hurst et al. (2010) also calculated the percentage change of aggregate wealth when a group of households engaged in an occupation with low income risk is moved to another occupation with high income risk. As the primary income source cannot reflect the risk profile of the household precisely, we performed two simulations to gauge the importance of precautionary saving following Carroll, Dynan, and Krane (2003) and Carroll and Samwick (1998). The first simulation took the households at the mean level of wealth as representative for the whole sample, while the second one includes all the information on the distribution of wealth and income risk. The latter predicted a higher percentage change of aggregate wealth than the former because the distribution of wealth is generally heavily right-skewed.

To facilitate the comparison with existing studies using different estimation strategies, we report the simulation results for all the four model specifications in Table 4.2. As reported in Table 4.3, for the first simulation, our results indicate that when income risk is completely eliminated for a representative household at the mean level of wealth, total net wealth drops by 10.6, 9.4, 44.6, and 65.6 percent under the four regressions, respectively. Total net wealth of rural households at the mean level of wealth will increase by 6.1 and 5.4 percent in OLS and median regressions in response to a 1/2 standard deviation increase in log income variability. Under IV Models 1 and 2, total net wealth can rise up to 11.8 and 20.2 percent.

Table 4.3—Results of two simulations on the strength of precautionary saving (%)

$ln(v^*)$[a]	Change of wealth	OLS	Median	IV Model 1	IV Model 2
Simulation 1[b]					
0	decreasing	10.6	9.4	44.6	65.6
$\ln(\hat{v})^1$+0.5SD	increasing	6.1	5.4	11.8	20.2
Simulation 2[c]					
0^{th}	decreasing	10.8	9.6	52.7	71.7
50^{th}	decreasing	4.2	3.7	15.8	19.5

Source: Authors' estimations.

Notes: .[a] $ln(v^*)$ is the new income risk set up in two simulations, and $ln\ (\hat{v})$ is the real income risk under OLS and median regressions, and predicted income risk at the second-stage regression under IV Model 1 and IV Model 2.

[b] Simulation 1 is set up for rural households at the mean level of wealth, which are taken as representative households for the whole sample. It calculates the percentage change of wealth when $ln(v^*) = 0$ and $ln(v^*) = ln\ (\hat{v})$+0.5SD. SD is the standard deviation of $ln\ (\hat{v})$.

[c] Simulation 2 is set up for each rural household in the sample, because households at the mean level of wealth might not be a good representative for the whole sample due to the heavily right-skewed distribution of wealth in general. It calculates the percentage change of wealth when $ln(v^*)$ is set at 0^{th} and 50^{th} percentile of $ln\ (\hat{v})$, respectively.

For the second simulation, aggregate wealth drops by 10.8, 9.6, 52.7, and 71.7 percent if income risk is set at the 0^{th} percentile of log income variability, and 4.2, 3.7, 15.8, and 19.5 percent at the 50^{th} percentile of log income variability under four regressions, respectively. The results of the two simulations are consistent when income risk is completely eliminated or set at the minimum level in our sample, and the change in wealth is smaller when income risk is completely eliminated in the first simulation, confirming our expectation of right skewness of wealth. Both simulation results indicate that the precautionary motive is an important reason for rural households in Zhejiang to hold a considerable amount of wealth.

Robustness Tests

Three tests are performed to test the robustness of estimated strength of precautionary saving. In the first test, we adopt relative equivalent precautionary premium as an alternative measure of income risks. The second test extends the wealth measures from total net worth to three other ones. Last, we trim the extreme values to check the impact of outliers by dropping observations with the five largest and smallest log wealth ratios. For all robustness tests except the first one (only re-estimated with OLS and median regressions), we re-estimate the OLS, median, and IV Models 1 and 2 regressions, and report the results in Table 4.4. The results from Table 4.2 are reproduced as baseline for easier comparison.

Alternative Measure of Income Risk

We have confirmed the positive correlation between wealth holdings and income variability in the previous discussion. Will the relation hold when income variability is replaced by another proxy of income risk measured by consumption fluctuations–equivalent precautionary premium (EPP)? Following Carroll and Samwick (1998), when utility function takes the form of CRRA, EPP is calculated as

$$\psi = \bar{c}\left(1 - [E(X)^{-\rho}]^{-\frac{1}{\rho}}\right), \tag{15}$$

where $\bar{c}$ is the level surrounded by a randomly distributed consumption c with a multiplicative shock X, that is, $c = \bar{c}X$. ρ is the coefficient of relative risk aversion, and we assume ρ to take the values of 3 and 5. Following Carroll and Samwick (1998), we transform EPP into its unitless counterpart-relative equivalent precautionary premium (REPP):

$$\frac{\psi}{\bar{c}} = 1 - [E(X)^{-\rho}]^{-\frac{1}{\rho}}. \tag{16}$$

The estimated coefficients of REPP in OLS regressions are not significant but are significant in median regressions (top panel of Table 4.4). The coefficients are 0.204 and 0.348 when ρ takes the values of 3 and 5, respectively. Since the baseline result from median regression falls between them, it implies that the coefficient of relative risk aversion ρ is between 3 and 5 at the median wealth level, indicating a considerably high level of risk aversion and confirming the prudence of rural households.

Alternative Measures of Wealth

Theoretical analyses treat various assets with distinctive liquidity in the same way, ignoring transaction costs associated with their liquidation, which are required to buffer income fluctuations in the real world. In order to test whether our hypothesis still holds when wealth is measured in other forms of assets, we extend the definition of wealth to include other assets based on their liquidity. Saving is the most liquid asset, including cash in hand, savings account, grain stock, loans lent, principal, and dividend of insurance. It is followed by productive capital assets that are frequently exchanged as recorded in our dataset. Consumer durables are the least liquid asset because they will be greatly devaluated after purchase due to high transaction costs for liquidation.

Asset liquidity 1 only includes saving, the most liquid component of total net worth. Asset liquidity 2 includes saving plus productive capital assets, and asset liquidity 3 adds consumer durables to asset liquidity 2. Asset liquidity 4 refers to asset liquidity 3 plus houses, which is the baseline model. This test can also help us detect the preferred form of assets for storing precautionary savings in rural households.

All the coefficients of income variability are significant, except those from IV Model 1 (middle panel of Table 4.4). They prove that regardless of the liquidity of assets, the positive association between wealth holdings and income risk always holds. Furthermore, in OLS and median regressions, the coefficients first increase when productive capital assets are added to savings and later continuously drop after consumer durables and houses are added. The variation suggests that rural households in Zhejiang stock their precautionary wealth mainly in the form of liquid assets. Contrary to this, the estimates in IV Model 2 keep rising when more illiquid components of wealth are added. This trend is opposite to the one reflected by the results of the OLS and median regressions, which might encourage further study on the portfolio choice of rural households in the presence of income risk.

Removing Extreme Values

Some studies estimate the wealth ratio equation by applying a quantile regression to avoid the impacts of outliers (Lusardi 1998; Jalan and Ravillion 2001), because the distribution of wealth can have a long tail to the right. To check whether outliers affect our results, we trim the full sample by deleting the observations with the five largest and smallest log wealth ratios. As presented in the last row of Table 4.4, the estimates of the four regressions are all significant and slightly different from the baseline results, indicating that our results are robust in spite of the outliers.

Table 4.4—Robustness tests[a], dependent variable = log (total net worth/permanent income)

	OLS		Median		IV Model 1[b]				IV Model 2[b]				Obs
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	UID	OID	Coef.	S.E.	UID	OID	
Baseline	0.366***	.092	0.325***	.031	1.935*	1.004	0.151	0.634	3.463***	1.349	0.999	0.220	6934
Alternative measures of income risk[c]													
REPP (=3)	0.224	.260	0.204**	.091	—	—	—	—	—	—	—	—	6934
REPP (=5)	0.345	.377	0.348***	.131	—	—	—	—	—	—	—	—	6934
Alternative measures of wealth[d]													
Asset liquidity I	0.489***	.110	0.472***	.046	-0.262	.286	0.062	0.345	2.649***	.787	0.990	0.032	4582
Asset liquidity II	0.536***	.107	0.521***	.051	-0.062	.562	0.004	0.031	3.249***	.921	0.986	0.599	4973
Asset liquidity III	0.532***	.101	0.515***	.042	0.629	.428	0.002	0.166	3.442***	.977	0.996	0.336	5418
Asset liquidity IV	0.366***	.092	0.325***	.031	1.935*	1.004	0.151	0.634	3.463***	1.349	0.999	0.220	6934
Remove extreme value	0.374***	.087	0.321***	.028	1.961*	1.007	0.139	0.721	3.364***	1.196	0.997	0.085	6924

Source: Authors' estimations.

Notes: [a] Only estimated coefficients of the proxy of income risk are reported. The proxy of income risk is income variability except for the first set of robustness test when income variability is replaced by the relative equivalent precautionary premium.

[b] IV Model 1 and IV Model 2 refer to the IV/GMM regression with IV selected from household and village levels, respectively.

[c] REPP refers to the relative equivalent precautionary premium, and coefficient of relative risk aversion.

[d] Asset liquidity I refers to savings, asset liquidity II adds productive capital assets to asset liquidity I, and asset liquidity III adds consumer durables to asset liquidity II. Asset liquidity IV refers to asset liquidity III plus houses, which is our baseline model. Log transformation allows 4,582, 4,973, 5,418 and 6,934 observations into the wealth ratio equation.

*,**, and *** indicate significance levels of 10, 5, and 1 percent, respectively.

5. FURTHER DISCUSSION

The gap between the estimates obtained from OLS/median regressions and those from IV Models 1 and 2 reflects the possible extent of downward bias caused by measurement error. These large disparities between OLS and IV estimates are also observed in the existing representative studies listed in Table 5.1. Guiso, Jappelli, and Terlizzese (1992) apply OLS and estimate that precautionary savings contribute to 1.8 percent of wealth accumulation. Using the same measurement of income risk and the same dataset, Lusardi (1997) estimates the contribution of precautionary saving is 10 times larger, at 20 to 24 percent, based on a two-stage IV method. In addition, although these representative studies do not completely share the same criteria for transforming the estimated coefficients of the measures of income risk into the strength of precautionary saving, IV results are generally higher than those of OLS and quantile regressions.

After addressing the problem of measurement error, we choose the results of IV Model 2 instead of IV Model 1. Idiosyncratic components of income risk are extensively documented to be larger than village-level common components (Dercon 2005), and we tried human capital variables as IV, which are widely applied and valid for urban households (see, for example, Carroll and Samwick 1997, 1998). The performance of IV Model 1 is, however, much less robust than that of IV Model 2 in the second robustness tests. The poor robustness of IV Model 1 of household IV can probably be attributed to two causes. First, the variables describing social connections and income structure have been used as controls to proxy the impacts of risk preference on wealth accumulation, leaving few candidates for IV at the household level. Second, an OLS regression of income variability on household characteristics indicates that human capital variables cannot capture rural households' ability to take up risk: $F(4,426)=0.55$, $p=0.6985$. This is consistent with the fact that the majority of Chinese farmers who have accumulated wealth in the past three decades received relatively low levels of education (Zhang, Huang, and Rozelle 2002). In IV Model 2, we construct IVs describing income structure at the village level to avoid using individual household's income structure. This practice is motivated by the fact that income portfolios of rural households in a village are greatly affected by the village's characteristics, such as natural endowment, technological tradition, and infrastructure. Despite all the efforts to select suitable IVs and the robustness of IV Model 2, our estimated strength of precautionary saving might be somewhat overstated as the riskier income compositions of the rich and the majority of households in the village are likely overrepresented in the income structure at the village level due to our approaches of constructing IVs.

Table 5.1—Summary of existing studies on precautionary saving using the method of regression evidence

Measures of income risks	Country	Estimation methods	Estimated strength of precautionary saving[a]	
			Mean level (%)	Aggregate level (%)
Income Variability				
Carroll and Samwick (1997)	U.S.	IV/2SLS	4.0	—
Kazarosian (1997)	U.S.	OLS	14.5	—
Jalan and Ravallion (2000)	China	Quantile	3.7	
Hurst et al. (2010)	U.S.	IV/2SLS	—	47.0(0th)
Equivalent Precautionary Premium				
Carroll and Samwick (1998)[b]	U.S.	IV/2SLS	—	45.0(0th); 2.0(50th)
Subjective Probability of Income Growth				
Guiso, Jappelli, and Terlizzese (1992)	Italy	OLS	1.8	—
Lusardi (1997)	U.S.	IV/2SLS	20.0-24.0	—
Arrondel (2002)	France	OLS	3.9-4.6	—
Subjective Probability of Job Loss				
Lusardi(1998)	U.S.	OLS,Quantile	0.8-1.5	—
Probability of Job Loss				
Carroll, Dynan, and Krane (2003)	U.S.	IV/2SLS	17.0	—
Dummy for Civil Servant				
Fuchs-Schundeln and Schundeln (2005)	Germany	OLS	22.0	—

Source: Authors' compilation.

Notes:[a] Strength of precautionary saving is gauged in two simulations: (1) Simulation 1: the percentage change of wealth for households at the mean level of wealth in a response to a 1/2 standard deviation increase in income variability, denoted as mean level; (2) Simulation 2: the percentage change of aggregate wealth if income risk of each household in the sample is set at the 0th and 50th percentile of income variability, respectively, denoted as aggregate level.

[b] Carroll and Samwick (1998) also apply log variance of log income as the proxy of income risk. Since they gauge their strength of precautionary saving based on the estimated coefficient of equivalent precautionary premium, we sort this study into the category taking equivalent precautionary premium as the measure of income risk.

Compared to the representative studies listed in Table 5.1, the estimated strength of precautionary saving calculated in our simulations are among the highest. First, using the same proxy of income risk—income variability—our estimate is higher than those that do not apply an IV strategy due to the distinctive estimation methods discussed above. For example, Jalan and Ravallion (2001) estimate a quantile regression and find that precautionary saving only takes up 3.7 percent of net worth for rural households in four Chinese provinces during 1985–90. This is slightly lower than the result of our median regression. And our data cover an additional period after 1992, during which precautionary motive is probably strengthened in the context of the accelerated transition to a market economy. Second, comparing across different proxies of income risk, our result based on income variability is larger than those of the subjective and real probability indexes, with the exception of Lusardi (1997). This is because the former covers a wider range of income fluctuations than the latter. Third, based on the same proxy of income risk, same simulation strategy, similar estimation strategy of IV estimation but using different IVs, our estimated strength for rural households in China is higher than that for urban households in developed countries. Carroll and Samwick (1998) and Hurst et al. (2010) report that aggregate wealth will drop by 45 and 47 percent, respectively, when income risk is set at its sample minimum. The strength of precautionary saving calculated in the second simulation depends on three factors: estimated coefficient of the proxy of income risk, the distributions of wealth, and income risk. Simply comparing the estimate of the proxy of income risk, our result of 3.463 is around five times that of Carroll and Samwick (1998), 0.679. But our estimated strength of precautionary saving is only higher than theirs by roughly 60 percent. Without precise information on the distributions of wealth and income risk in their sample, it could only be speculated that wealth and/or income risk are distributed more discretely in their sample than ours. The gap reflects a stronger precautionary motive in rural households in Zhejiang, and this might be attributed to the fact that the institutions for ex post consumption smoothing besides precautionary saving, such as social insurance systems and rural formal credit and insurance markets, are generally less developed and well-functioning in most rural areas of developing countries including China.

Other studies by Chinese scholars also reveal rural households' prudent behavior in the post-reform period. Du and Deng (2005) estimate a log-linearized Euler equation with time series data of consumption per capita from 1978 to 2002 and estimate the coefficient of relative risk aversion to be 5.8. Wan, Shi, and Tang (2008) use a similar RCRE dataset of five provinces in 1995–2000 to estimate the determinants of the saving rate. They find that the households who allocate more laborers and earn more income from nonfarm activities maintain a significantly higher saving rate, indicating that a risky income structure results in higher strength of precautionary saving. Liu and Ma (2007) also estimate a wealth ratio equation using three waves of the China Economic, Population, Health and Nutrition Survey in 1997, 2000, and 2004. Their estimated coefficient of the income risk proxy, deviation of real income to permanent income, is 8.2, reflecting a remarkable response of wealth holdings to income fluctuations.

As observed in many developing countries, rural Chinese households rely heavily on precautionary saving when faced with the uncertainty introduced by economic reform, probably due to its lower cost relative to other ex post coping strategies, including rural formal credit and insurance markets, rural safety nets, labor markets, and informal risk-sharing networks within villages. These risk coping alternatives are undergoing transformation to align with China's broader institutional transition.

Rural households in China can easily access safe saving services in their respective townships, which are supported by extensive financial branch networks and are insured by the central government (Shen et al. 2010). Despite the wide coverage, credit constraints are pervasive in rural areas and the rural financial sector is far from a modern and efficient financial system to support economic growth in rural areas (Shen and Cheng 2004). Agricultural insurance is wandering between commercial and subsidized modes since it has been rebuilt in the post-reform period, and the majority of smallholders are discouraged from participating in agricultural insurance schemes (Shi and Meng 2003). Meanwhile, rural social security systems are struggling to adapt to the new fiscal foundation through reconstruction after their collapse with the communes. Rural health reform does not significantly reduce the out-of-pocket payments (Wagstaff et al. 2009) and the newly established safety net is only focused on meeting the food demands of the poor (Li et al. 2007).

The gradual integration of the labor market affects rural households' ability to smooth consumption in two countervailing ways. On one hand, a shift in labor supply after an external shock is an effective coping approach (Giles 2006). On the other hand, high mobility due to migration might undermine informal risk-sharing mechanisms within villages (Morten 2010). The informal risk-sharing networks within villages are gradually replaced by impersonal market institutions. Generally speaking, the closer the villages are to urban areas, the more weakened the informal networks are.

That rural households exhibit high levels of prudence in the context of institutional transition enables better understanding of three phenomena in China, which might have implications for other developing countries. First, rural households' high level of prudence is one of the important reasons for the high saving rate among rural households in China. The saving rate of rural households remained at as high a level as their urban counterparts after compulsory force on saving was removed during the period of decentralization (Qian 1988). The increasing saving rate has attracted even more attention since the 1990s, when China's economic growth was characterized by high export and investment but low consumption. A strong precautionary motive due to increased uncertainty after economic reform has been proposed as one of the driving causes of this (Zhang and Wan 2004). Second, rural households' high level of prudence contributes to rural households' low take-up of agricultural insurance. Although agricultural insurance is considered to have great potential to reduce welfare loss caused by covariate weather variations, rural households' low take-up of agricultural insurance is pervasive in China, as in many other countries. Because so far smallholders in China are still contributing the majority of several strategic crops, poultry, and livestock products covered by agricultural insurance, the insured income accounts for a limited share of total net income for those households. Thus, agricultural insurance is not an effective strategy to mitigate overall income risk faced by those households, and they probably resort to precautionary saving for better self-insurance. Third, rural households' high level of prudence might undermine informal risk-sharing networks within villages. The capacity of informal, social capital-based, risk-sharing networks within villages to help rural households protect against shocks have been observed to be weakening with the increasing penetration of marketization after economic reform in China (Lu, Sato, and Zhang 2008). While the enhanced mobility of village members allowed by migration undermines the participation in informal networks, precautionary saving could also crowd out the informal networks (Chandrasekhar, Kinan, and Larreguy 2009). When rural households with considerable wealth accumulation benefit more from precautionary saving as self-insurance, they appear likelier to quit the informal networks, thereby impairing those networks' capacity to insulate against negative shocks.

6. CONCLUSIONS

Institutional transition introduced by economic reform in the late 1970s in China brought considerable uncertainty to rural households. Based on a long panel of data in Zhejiang province over 1986–2006, this paper analyzes rural households' precautionary saving behavior in the context of institutional transition. It examines the hypothesis implied by the buffer-stock model that an increase in uncertainty will result in an increase in the target ratio of wealth to permanent income. Our results strongly support the notion that rural households hold wealth to insulate against income risk, and that they exhibit a high level of prudence in the post-reform period characterized by high income risk. The results can be attributed to the relatively low cost of applying precautionary saving to insulate against income risk, compared with other ex post coping strategies. The results help better understanding of three phenomena in China, including high saving rate, low uptake of agricultural insurance, and weakening informal risk-sharing networks within villages.

Our findings suggest that any development policies aimed at reducing income risk in rural areas should consider the fact that rural households actually acquire a wide range of risk management and coping strategies. As income increases and wealth accumulation accelerates in developing countries, rural households are more capable of smoothing consumption through precautionary saving. Thus, development policies should focus on mitigating severe income shocks caused by catastrophes and major diseases that are beyond individual household's ability to cope and that may incur huge welfare losses. Additionally, in order to insulate against agricultural production risk, increasing uptake of agricultural insurance might be more effective in specialized production zones and for large-scale farmers. But for the majority of smallholders who derive income from multiple economic activities, improving the effective coverage of social safety nets might be more helpful than increasing the supply of agricultural insurance.

Our results also suggest several areas for future study with respect to risk management and coping strategies in developing countries. While the governments in developing countries attempt to improve the functioning of formal insurance schemes and financial markets and extend the coverage of safety nets in rural areas, the effectiveness of these policy interventions is contingent upon the extent to which precautionary saving is crowded out by those public efforts. Meanwhile, precautionary saving can only act as a partial insurance at the household level. Poor households who cannot be better off with precautionary saving alone might be inclined to reduce their exposure to income risk through the strategies of income diversification and skewing, such as exchanging a decreased income level for less income variability, or refusing to adopt risky but profitable inputs and varieties. Thus, studies on poor households' income smoothing behavior deserve more attention to promote income mobility and reduce inequality in rural areas.

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