China Economic Review 29 (2014) 27–45

Contents lists available at ScienceDirect

China Economic Review

Risk, under-investment in agricultural assets and dynamic asset poverty in rural China

Jing YOU *

School of Agricultural Economics and Rural Development, Renmin University of China, China

ARTICLE INFO

Article history:
Received 21 July 2012
Received in revised form 5 February 2014
Accepted 5 February 2014
Available online 13 February 2014

JEL classification:
I32
O12
O53

Keywords:
Risk
Asset dynamics
Poverty trap
Rural China

ABSTRACT

This paper seeks new insight into the reasons for persistent hardship in some Chinese rural households from the perspective of assets, stressing the long-run implications of shocks and risk on households' agricultural asset holdings. Households show a tendency to hold onto substantial savings to cope with possible negative shocks, and are predisposed to specialize in low-risk low-return agriculture under ex ante credit constraints and the fear of low welfare outcomes if production plans should be unsuccessful. Overall, households' responses to uninsured shocks and risk cause inefficiencies and deficiencies of investment in agricultural asset accumulation. Multiple equilibria in the dynamics of household agricultural assets as well as under-investment as a response to risk make some households less able to earn income above the poverty line and keep them trapped in long-term low-equilibrium asset poverty.

1. Introduction

According to official governmental figures, over the last three decades, 230 million people have escaped poverty in rural areas of China. This has been reflected in a sharp reduction in the poverty headcount ratio from 30.7% in 1978 to 2.3% in 2006. However, it is also worth noting that 80% of this poverty reduction happened before 1996.[1] Ravallion and Chen (2007) find that, since the late 1990s, poverty appears to have become more "concentrated" and "persistent" as the incomes of the rural poor have stagnated while others' incomes have risen, with actual increases in rural poverty in 1999, 2000 and 2001 relative to 1998.

But why has poverty persisted in rural China? Studies of rural China and from the rest of the world (sub-Saharan Africa in particular) might help answer this question. Studies of rural China have identified explanations for the persistence of rural poverty: a) inadequate endowments, such as those associated with living in remote or otherwise unfavorable geographical locations (Jalan & Ravallion, 2002), which reduce the productivity of farm households' investment (Jalan & Ravallion, 1999); b) poor education (Knight, Li, & Deng, 2009, 2010); c) lack of access to prosperous economic activities in addition to cropping (Glauben, Herzfeld, Rozelle, & Wang, 2012); d) social exclusion in an underclass associated with ethnicity and gender (Cao, Wang, & Wang, 2009; Hebel, 2003); and e) a range of institutional and market failures (Cai, 2010; Jacoby, Li, & Rozelle, 2002).

In addition to these studies of China, there is a growing body of evidence from African economies which suggests that risk and shocks can be a further cause of persistent poverty through their impact on households' investment in accumulation of key productive assets (Carter, Little, Mogues, & Negatu, 2007; Dercon, 2004, 2006, 2009; Dercon & Christiaensen, 2011; Elbers, Gunning, & Kinsey,

* School of Agricultural Economics and Rural Development, Renmin University of China, 59 Zhongguancun Street, Beijing 100872, China. Tel.: +86 10 6251 1061; fax: +86 10 6251 1064.
E-mail address: jing.you@ruc.edu.cn.

[1] The figures in this and the previous two sentences are the author's calculations based on data from Poverty Monitoring Report of Rural China 2008.

http://dx.doi.org/10.1016/j.chieco.2014.02.002
1043-951X

2007; Foster & Rosenzweig, 2010; Lybbert, Barrett, Desta, & Coppock, 2004; Rosenzweig & Binswanger, 1993).[2] These studies find that exposure to uninsured risk and shocks tends to reduce farm households' incentives to invest in high-return but risky agriculture. This choice would then lead them to low-equilibrium asset holdings bringing lower long-term income (Adato, Carter, & May, 2006; Barrett et al., 2006; Carter et al., 2007), which means they would fall below the accepted poverty line and suffer from persistent poverty.[3] Consequently, seemingly short-lived risk and shocks can generate persistent poverty in the long-term by undermining households' asset base. Going one step further, Carter and Lybbert (2012) use threshold estimation to locate a dynamic asset threshold around which households undergoing shocks would prefer to smooth assets rather than consumption.

This paper aims to investigate whether prolonged hardship for some Chinese rural households can be attributed to this risk-induced dynamic asset poverty. Risk has been found to affect Chinese rural households' decisions on agricultural production and investment plans. Huang, Lin, and Rozelle (2003) find that Chinese farm households do not use hybrid or high-yielding varieties that might provide them with higher incomes. During field work, the directors of China Health and Nutrition Surveys (CHNS) also observed that many rural households did not invest at all for three to four years after a relatively large-scale investment in agriculture had failed.[4] These observations suggest that households' exposure to uninsured risk and shocks would force them to renounce profitable investment in productive assets in favor of low-return but less risky agricultural production, and in that case, such behavioral responses bring them low income forcing them to continue in low-return production. A way of breaking this vicious circle is needed if policy makers are to help improve the conditions of the poor and promote self-reinforcing growth out of poverty through that steady investment in profitable agricultural asset accumulation which in the past helped rural China reduce poverty (Montalvo & Ravallion, 2010). However, there is a paucity of studies examining the impact of risk and shocks on Chinese rural households' long-term well-being in relation to their asset holdings. There are some studies of the extent of precautionary savings following negative shocks in the context of rural China (e.g., Giles & Yoo, 2007; Jin, Chen, Yu, & Huang, 2011) but, as we will elaborate in the next section, this is only the first part of the story where risk-induced dynamic poverty is concerned and they pay little attention to the consequences of risk and shocks for household asset holdings which can form the foundation for long-term income generation.

This paper seeks to contribute to the literature in three ways. First, using a representative household panel (CHNS, 1989–2006), it provides the first comprehensive econometric investigation of the existence of risk-induced dynamic asset poverty in rural China. By focusing on the impact of risk on a household's asset base, it may give new insight into the root causes of persistently low income in poor rural households. Second, it is a methodological improvement for studying household asset dynamics. Insufficient capture of higher order nonlinearity and households' underlying livelihood strategies has hampered fully parametric and non-parametric methods employed in the existing literature. This paper uses a semi-parametric approach to describe asset dynamics which is less susceptible to the above problems.[5] Third, it draws upon counterfactual simulations to distinguish potential downside risks from realized shocks as Dercon and Christiaensen (2011) and gauges household-specific marginal effects of risk and other explanatory variables of interest. We do this because, in latent variable regressions in many existing studies cited above, interpretation is based on estimates of household responses to risk, while the magnitude of the effects is still unclear and there might be significant heterogeneity across households caused by either their observed or unobserved characteristics. The calculations of marginal effects will show the role of various risk-enhancing and risk-mitigating factors in asset dynamics and thus permit household heterogeneity to be addressed. We should then be able to offer more informative interpretations.

The analysis finds multiple equilibria in household asset dynamics. Households' behavioral responses to uninsured shocks and risk cause deficiencies and inefficiencies of investment in profitable agricultural asset accumulation. This is likely to lead some households into low-equilibrium asset traps resulting in low income in the long-term, instead of converging to the high-equilibrium asset level and finally escaping from poverty. In other words, there may be risk-induced and asset-based persistent poverty.

The remainder of this paper is organized as follows. The next section spells out two behavioral mechanisms underpinning risk-induced dynamic asset poverty. Section 3 describes the dataset and explores the shape of asset dynamics. Section 4 presents the econometric specifications for two mechanisms and their empirical results are discussed in Section 5. Section 6 concludes.

2. The role of risk vis-à-vis household dynamic welfare status

Risk has two kinds of effect on household welfare and poverty status (Clarke & Dercon, 2009). Risk in the form of possible negative shocks may knock households into poverty, but they can, in principle, adjust and regain the pre-shock living standards as the shocks dissipate. However, the risk of some negative shocks (e.g., insecure asset and investment portfolios) may cause changes in household behavior and/or preferences which make outcomes worse than they might otherwise be. Such behavioral responses to risk have a cumulative impact on a household's welfare.

[2] McKay and Perge (2013) examine countries in Asia and Latin America as well but the asset-based poverty traps appear to exist in only a few African and Latin American countries. There are mixed empirical studies on this topic which will be discussed in Section 3.2.

[3] Lipton (1968) and recently Baulch (2011) have reached similar conclusions using other non-asset based methods.

[4] This can be found at: http://www.cpc.unc.edu/projects/china/data/datasets/Household%20Income%20Variable%20Construction.pdf [accessed 21 July 2012].

[5] Naschold (2012) also uses a semi-parametric approach to model asset dynamics — he uses penalized spline estimators based on a chosen total number of knots. The methodology in this paper is more general than that as we will draw upon non-parametric estimators (LOESS and kernel) to model lagged assets. This, together with a fully parametric part controlling for other attributes to asset accumulation, forms our semi-parametric regression for asset dynamics.

2.1. Ex post responses to shocks: self-insurance behavior

Households confront various shocks. Negative shocks include falls in assets and income, rainfall, drought and events such as illness and death (Carter et al., 2007; Dercon, 2004; Dercon, Hoddinott, & Woldehanna, 2005; Quisumbing & Baulch, 2013). They can bring significant consumption shortfalls to households, and there is no effective risk sharing for households within the village to minimize these consumption shortfalls (Morduch, 1995; Dercon & Christiaensen, 2011; Jalan & Ravallion, 1999 for rural China). In such circumstances, poorer households may protect themselves against adverse shocks by liquidating or trading productive assets (Dercon et al., 2005; Rosenzweig & Wolpin, 1993) and/or holding substantial precautionary savings in non-productive forms such as grain stocks and cash, which has been widely observed among Chinese rural households (Giles & Yoo, 2007; Jalan & Ravallion, 2001; Jin et al., 2011; Park, 2006).

However, neither of the above behavioral responses is allocatively efficient. They tend to reduce households' productive investment. Specifically, the liquidation of productive assets implies that households may choose to subsist on a lower but more stable income if offered a trade-off against higher but riskier predicted income. At the same time, under credit constraints, substantial precautionary savings discourage households from making profitable agricultural investment because of their irreversibility and non-divisibility (Fafchamps, 2003).

2.2. Ex ante responses to risk: income-skewing behavior

Households are not affected only by the shocks themselves, but also adjust their behavior towards risk and uncertainty. Poor rural economies are rife with risk and often characterized by ill-functioning financial markets. Under credit/liquidity constraints and limited insurance, poorer farm households are forced to choose low-risk low-return agricultural production in order to reduce their exposure to risk (Foster & Rosenzweig, 2010).

Two reasons for this choice have been identified in the existing literature. First, high-value production usually requires lumpy initial input and higher educational level (Dercon, 1998), but poorer households often cannot afford these (McKenzie & Woodruff, 2006). Second, households' productive investment decisions can be shackled by their "loss aversion", i.e., the fear of bad consumption outcomes if the high-value production were to be unsuccessful (Dercon, 2006).[6] This may be due to non-separability in household behavior. Household consumption characteristics are both consequences and correlates of their production choices (Bowlus & Sicular, 2003 for rural China; de Janvry & Sadoulet, 2006). Households' differentiated capabilities of smoothing consumption following shocks may also influence their uptake of risk (Hoogeveen, 2001). In this sense, the ex post and ex ante mechanisms are not independent of each other but, jointly, they lead households to low-equilibrium agricultural production which is less risky but less profitable.[7]

3. Data

3.1. Data source

We extract a balanced panel containing 1446 rural households from China Health and Nutrition Surveys in 1989, 1991, 1993, 1997, 2000, 2004 and 2006.[8] The constructed panel covers 7 provinces from affluent regions along the coast to less developed areas in inland China, including Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou. As consumption data were not directly given in the CHNS, we calculate household consumption per capita based on information on household expenditure including food consumption which incorporates both self-produced food and that bought from markets, expenditure on durable goods, discounted value of housing and health and medical expenditure.[9] All monetary values are translated into real terms by the rural price index constructed by the CHNS team.

A typical concern with rotating panels is that potential bias in estimation may arise if the households that drop out of the panel follow systematically different paths of asset accumulation over time compared with those remaining in the panel. This may be particularly problematic in studying household coping strategies in response to shocks if a household's drop-out is a result of suffering a catastrophic negative shock (Jalan & Ravallion, 2005). In other words, the attrition may be endogenous to the shocks. We carry out various diagnostic tests to investigate whether our panel is subject to this attrition problem.[10] From these tests, it can be reasonably inferred that attrition is not informative on households' livelihoods and paths of asset accumulation.

[6] Dercon (2006) and Fafchamps (2009) argue that this fear should be viewed as a joint result of rational motives under risk aversion and behavioral motives observed from field experiments, so that even normally risk neutral households may not be willing to invest because of extensive market failures and may well behave as if they are risk-averse.

[7] Morduch (1995) and Rosenzweig and Binswanger (1993) provide early empirical support. Dercon and Christiaensen (2011) present a theoretical model underlying this process.

[8] The CHNS defined "rural households" in the 1989 wave according to their household registration type and residence: a household was rural if it had a rural registration and was living in a village at the time of interview. We selected those "rural" households in the 1989 wave. From the pool, we picked up those who were re-interviewed in every subsequent wave until 2006 and continued to live in villages full-time.

[9] The constructed consumption data appear to be consistent with the one in Rural Household Surveys conducted by the National Bureau of Statistics. The poverty incidence drawn from our measure also echoes the general findings of poverty changes in rural China. Overall, consumption measure appears to be plausible. The comparison and investigation of the features of constructed consumption data are available from the author upon request.

[10] Attrition could stem from the observed and/or unobserved characteristics. We investigated the former case by the added regressor test as Giesbert and Schindler (2010) and the latter by a Heckman-type selection method proposed by Wooldridge (2002). Detailed test procedure and results are available upon request.

Table 1
Components of household assets.
Source: China Health and Nutritional Surveys (1989–2006).

Capital type	Category	Components
Physical capital	Housing	Age of house; roof/floor/wall material; size of dwelling; drinking water source; lighting source; toilet type; main cooking fuel
	Consumer durables	Types of transport; living/entertainment durables[a]
Productive capital	Agricultural assets	Fixed assets including the quantity of different types of farming machinery & irrigation;[b] financial assets including money spent on seed, fertilizers, labor, etc.
	Business assets	Fixed assets including the quantity of different types of commercial business equipment;[c] financial assets including money spent on raw materials, labor, etc.
Human capital	Education	Weighted years of schooling

[a] Transport includes bicycles, tricycles, motorcycles and automobiles. The living and entertainment durable goods include radios, VCRs, televisions, washing machines, refrigerators, air conditioning, sewing machines, electric fans, big wall clocks and cameras.
[b] Farm machines include large or medium sized tractors, walking tractors, animal carts, irrigation equipment, power threshers and household water pumps. Land owned by households is not included, since in rural China, land is not transferable as it is allocated by local/village officials according to the number of household members. Land is not, therefore, a tangible asset that households can freely accumulate or divest.
[c] Commercial equipment that households use in their small business activities includes cooking equipment, carpentry equipment, haircutting equipment, sewing machines (excluding those treated as consumer durables that are used for daily life), welding machinery, small machine-shop tools or equipment and other unspecified equipment.

We construct asset indices to represent household assets, considering lack of data on the values of assets in the CHNS and bias that would arise if assets were correlated with measurement errors in income or consumption (Antman & McKenzie, 2007). Using the asset index to study households' poverty and long-term wealth also generates fewer errors compared with expenditure data (Sahn and Stifel, 2003).

Following Moser and Felton (2009), household assets are categorized into three elements – physical, productive and human capital – as shown in Table 1. We use Moser and Felton's (2009) regression method to construct human capital. In each wave, the individuals' log wage earned in labor markets is regressed on their different educational levels in terms of years of schooling, other individual controls (such as gender, age and the squared age), and provincial dummies accounting for other unobservables that may affect the role of education for income generation. Weights are the estimated coefficients for each educational level in each wave. The sum of weighted years of schooling for individuals adds to the household human capital.[11] The indices for the other four asset categories are constructed separately by using polychoric Principal Component Analysis (PCA) developed by Kolenikov and Angeles (2009).[12] The polychoric PCA not only retains the strengths of standard PCA initially introduced by Filmer and Pritchett (2001), but also takes advantage of ordinal asset data: a higher value of asset index represents not only the ownership of a certain kind of assets, but also better quality for the same kind of assets (e.g., owning a black and white TV as opposed to color).[13] It should outperform the regression-based method pioneered by Adato et al. (2006) without imposing a pre-determined relationship between consumption and assets, as their method raises the concern of reversed causality in the subsequent consumption regression.

Table 2 displays asset portfolios across income groups. The poorest quintile appears to invest mainly in agricultural production and consumer durables, while the richest quintile engages more in both agricultural production and business. Although both the poorest and richest quintiles tend to pursue more agricultural production than others, the rich enjoy on average 14.3% more predicted marginal returns on their agricultural asset holdings than the poor.[14] Agricultural assets are important sources of income for rural households, as more than 50% of sample households' income comes from agriculture and this proportion is on average 7 percentage points higher for the poor measured by per capita consumption against US$1.25/day than for the non-poor. As regards other kinds of asset, the wealthier the household, the more education, housing and consumer durables it can afford.

We include a wide range of shocks to better describe households' uncertain livelihoods. First, we construct two indicators of income shocks. Adopting Carter et al.'s (2007) definition, we calculated the proportion of those who are subject to income shortfall within the county to indicate income shocks at the aggregated (county) level.[15] It describes the magnitude of shocks which can be observed by all households within the county. In addition, we draw upon Jalan and Ravallion's (2001) panel income generation model with first-order autocorrelation in disturbances in each panel and estimate the severity of household-specific

[11] As Moser and Felton (2009), we use individual log wage income rather than log farm income as the dependent variable, considering that for Chinese farmers, education is more important for income from labor markets, while manual labor is more important for farm income. However, given this way of construction of human capital, it should be noted that our human capital index captures only port of the role of genuine human capital for households' income generation.
[12] The index for each asset category in Table 1 is the sum of weighted normalized asset components for that category. The weights are obtained by polychoric PCA for components of each asset category in each wave. Intuitively, positive weights are indicative of owning more other asset components, and vice versa. Zero weights mean that owning this kind of asset cannot convey information for ownership of other assets. Thus, the constructed household asset indices can be positive, negative or zero. The value of asset indices does not indicate the quantity of assets owned by the household, but the wealth order among households. Those with positive asset indices are wealthier than those with zero or negative asset indices. The technical detail of asset construction is upon request from the author.
[13] See Moser and Felton (2009) for detailed comparisons between the two methods.
[14] We employ a semi-parametric regression to calculate predicted returns to agricultural assets. This will be introduced in Section 3.2.
[15] Strictly speaking, this variable cannot be interpreted as covariate income shocks. Ideally, one may use village rainfall data to disentangle covariate income shocks. Unfortunately, data limitations of CHNS do not allow us to do so.

Table 2
Household asset portfolios, by quintile of permanent income[a] (1989–2006).
Source: Author's calculation based on data from the CHNS (1989–2006).

Quintile[c]	Agricultural assets	Business assets	Investment in consumer durables	Investment in housing	Human capital[b]
1 (poor)	0.050	−0.124	0.031	−0.038	5.871
2	−0.060	−0.062	−0.107	0.016	7.377
3	−0.031	−0.018	0.066	−0.046	8.242
4	0.005	0.072	0.002	0.042	8.729
5 (rich)	0.034	0.134	−0.010	0.020	10.068

[a] We estimate Jalan and Ravallion's (2001) income generation model and calculate predicted household intertemporal mean income as a proxy for household permanent income.
[b] Human capital is re-scaled by dividing the magnitude by 100 in order to compare it with the other four categories of assets.
[c] The figures are only comparable across quintiles. The values of different asset indices within the same income quintile cannot be compared with each other by construction.

income shocks. Specifically, we first derive household-specific income uncertainty which is the ratio of the variance of the estimated innovation errors over household permanent income calculated as the intertemporal mean predicted income, and then distinguish the negative uncertainty from the positive by multiplying minus one to that ratio if households' observed income is smaller than predicted. As shown in Fig. 1, over the sample period, 35% and 45% of the study population suffered idiosyncratic and covariate income shocks respectively. Households cannot protect themselves fully by informal risk-sharing arrangements within the village. For an average household, 18% of idiosyncratic income shocks and 43% of covariate income shocks are passed on to its consumption.[16] This indicates the possibility of the first mechanism by which uninsured shocks hit rural households' livelihoods.

Second, we distinguish between positive events and negative shocks: the number of household members who were ill in the previous four weeks, the number of deaths and whether the household met expenditure on a wedding, dowry or funeral in the previous year. Overwhelmingly, expenditure on weddings, dowries or funerals happened most frequently, followed by illness with an average 15% incidence over time.

Third, collective shocks due to bad or unexpected weather and institutional failures could substantially affect households' livelihood over a longer period (Dercon, 2006). The former are proxied by the share of sown land affected by various natural disasters in the sample province. Overall, 16% of sown areas were affected per year. The latter is measured by price shocks of agricultural input and output, since they reflect households' difficulties in obtaining input and inability to sell output which are indicative of distortions in the process of market reform (Dercon, 2006).[17] More specifically, the price shocks are calculated as percentage variations of real price indices of agricultural input and output relative to the preceding year. The descriptive statistics of all variables are listed in Table 3.

3.2. Asset dynamics and bifurcated livelihoods

Before proceeding, it is necessary to explore non-linearity and non-convexity in household asset dynamics, as only on identifying them can we posit the existence of possible poverty traps at a lower equilibrium. McKay and Perge (2013) examined asset dynamics in 5 countries, together with many empirical studies cited in Section 1, while the findings seem to be mixed. It is worth noting that they all use full or non-parametric methods which have been criticized by Carter and Barrett (2006). The former typically uses polynomials of assets in the right-hand side of the regression, while it is powerless in capturing higher order non-linearity. The latter, including kernel and locally weighted scatterplot smoothing (LOWESS) in the existing literature, overcomes this disadvantage, but cannot reflect households' underlying livelihood strategies in asset accumulation as no other covariates except assets are controlled for in the right-hand side of the regression.[18] Bearing these shortcomings in mind, we employ a semi-parametric model specification to deal simultaneously with challenges in full- and non-parametric methods. Each asset category at t, e.g., agricultural assets A_{ht} in Eq. (1), is regressed on previous asset holdings $t-1$ with an unknown function form $f(\cdot)$ and households' other characteristics controlled by the vector X:

$$A_{ht} = f\left(A_{h(t-1)}\right) + X\beta + \varepsilon_{ht}. \quad (1)$$

[16] We used Jalan and Ravallion's (1999) model specification to examine the hypothesis of perfect risk-sharing within the village. The log changes of household per capita consumption were regressed on log changes of household per capita income ($\Delta \ln income_{ht}$), log changes of household size ($\Delta \ln hhsize_{ht}$), and with and without village-time dummies, respectively. I estimated the models by one-step System-GMM (Blundell and Bond, 1998) to address possible endogenous income and household size. The second lags of endogenous household per capita income and household size are used as instruments. Detailed results are available upon request from the author.
[17] Unfortunately, CHNS does not allow us to include other important institutional issues that might affect households' behavior and *ex ante* asset portfolios, such as land expropriation, the rule of law and property rights (Dercon, 2009).
[18] In addition to the model specifications, McKay and Perge's (2013) mixed findings may also be caused by the fact that they combine different kinds of assets into a single index for studying the asset dynamics. This could be problematic as some kinds of assets may not be easily accumulated or divested, like housing and human capital. Therefore their combined asset index is less likely to suggest multiple equilibria, although some of the assets should otherwise have. We alternatively examine the dynamics for each kind of asset indices by using Eq. (1).

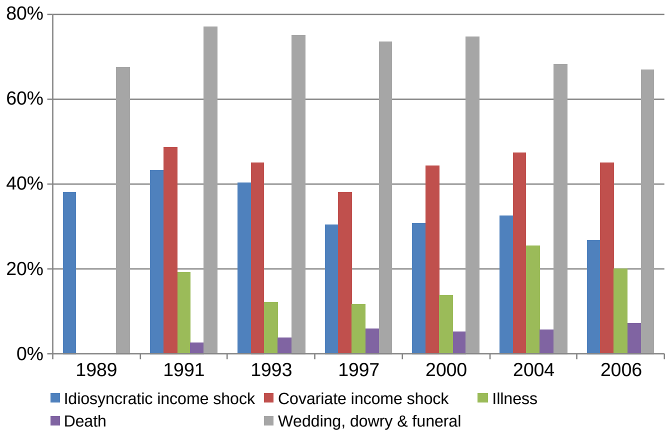

Fig. 1. Incidence of shocks. Source: Author's calculation based on data from the CHNS (1989–2006).

Empirically we let $f(\cdot)$ be an Epanechnikov kernel function to reflect non-linearity and estimate Eq. (1) by Lokshin's (2006) first-differencing estimation approach.[19]

We calculate the predicted assets at t ($\hat{A}_{ht}$) based on the estimators of Eq. (1). Then, Fig. 2 draws these predicted assets at t ($\hat{A}_{ht}$) against actual asset holdings at $t-1$ ($A_{h(t-1)}$), i.e., the semi-parametric relationship between them after controlling for other attributes in the parametric term. The asset equilibrium would be achieved where the agricultural asset dynamics cross the 45-degree line. Two stable equilibria (A_L and A_H) and one unstable equilibrium (A_0) emerge.[20] In the presence of locally increasing returns to agricultural assets,[21] those owning more agricultural assets than A_0 would optimally converge to A_H, which is also above the static asset poverty line, implying that they would be able to escape from poverty given sufficient time. By contrast, those facing credit constraints and lying below A_0 would sub-optimally slide towards A_L which is even lower than the static asset poverty line which is equivalent to the US$1.25/day adjusted to rural–urban price gap in China as Ravallion and Chen (2007). This means that they are not only living in poverty, but also are likely to stay in persistent poverty in the future as they lack sufficient assets to produce enough income to cross the poverty line. These households are subject to "needless chronic poverty" (Adato et al., 2006; Barnett, Barrett, & Skees, 2008) in the sense that they could have accumulated assets (i.e., on the growth route from A_0 to A_H) and ultimately risen above the asset poverty line had there been effective productive safety nets to prevent their falling below A_0.

The above analysis lends support to bifurcation in agricultural asset holdings and therefore diversified livelihoods with two equilibria over time. Furthermore, the lack of asset accumulation leading to high equilibrium for households underpins a medium- or longer-term inability to escape from poverty.[22]

4. Methodology

4.1. Coping with negative shocks

The ex post mechanism is modeled by the following specification drawn from Dercon and Christiaensen (2011). For the household h at time t, per capita consumption c_{ht} is regressed using a fixed-effects model:[23]

$$\ln c_{ht} = \gamma_1 A_{h(t-1)} + \sum_{j=1}^{J} \gamma_{2j} s_{htj} + \sum_{k=1}^{K} \gamma_{3k} B_{h(t-1)k} s_{ht}^{inc.} + \sum_{k=1}^{K} \gamma_{4k} B_{htk} s_{ht}^{inc.} I_{ht} + x_{ht}^{'} \gamma_5 + \alpha_h + \varepsilon_{ht} \qquad (2)$$

[19] We also implement Lokshin's (2006) specification test for the non-parametric f against parametric functions in terms of quadratic and cubic terms. Our semi-parametric specification is supported in all asset categories with significance levels varying from 1% to 5%.

[20] There is only one stable equilibrium for other asset categories. Therefore, low-equilibrium traps might not exist if one refers to the dynamics of non-agricultural assets.

[21] Actually Carter and Barrett (2006) list three prerequisites enabling the existence of non-convexity in asset dynamics, among which locally decreasing returns in the vicinity of a lower asset level and locally increasing returns to scale at a higher asset level are the most important anchor of the theory of asset-based poverty traps. Employing the above semi-parametric framework, we regress household per capita net income generated from agriculture on their agricultural asset holdings in $f(\cdot)$ and other household characteristics, and then calculate predicted income which represents the expected returns of agricultural assets. The predicted returns indeed first decrease and then increase as agricultural assets grow, which gives rise to non-convexity in asset dynamics.

[22] Evidence to this can be drawn from the dynamics of per capita household income and consumption. Using semi- and non-parametric means, we find a single equilibrium (higher than US$1.25/day) with slight concavity in both income and consumption, indicating the long recovery time from transitory income losses for the poor, which is also found by Jalan and Ravallion (2005).

[23] The Hausman test prefers fixed effects to random effects at 1% significance level.

Table 3
Descriptive statistics.
Source: Author's calculation based on data from the CHNS (1989–2006).

Variable	Mean	Std. dev.	Min	Max
ln(hh per capita consumption)	7.188	0.539	4.024	10.991
Agricultural assets	−0.001	0.680	−0.599	3.938
Business assets	0.001	0.789	−2.628	3.825
Consumer durables	−0.002	1.149	−2.876	2.514
Housing	−0.002	1.760	−2.379	9.001
Human capital	8.054	3.973	0	33.165
Covariate income shock	0.384	0.207	0	0.893
Idiosyncratic income shock	−5.32e-06	0.317	−2.954	2.668
No. of ill members	0.194	0.530	0	7
No. of deaths	0.046	0.218	0	2
Wedding, dowry & funeral (yes = 1)	0.719	0.450	0	1
price shock of agricultural input	0.044	0.074	−0.061	0.283
Price shock of agricultural output	0.030	0.110	−0.179	0.260
% sown land affected by natural disasters	0.163	0.059	0.050	0.298
hh size	4.235	1.517	1	13
Age of hh head	49.217	12.582	15	96
No. yrs. of edu. for hh head	5.854	3.640	0	17
% male members within hh	0.644	0.257	0	1
Dependency ratio	0.359	0.291	0	1
% local off farm employment within hh	0.491	0.340	0	1
Out-migration networks	0.015	0.035	0	0.366
Land-(on farm) labor ratio	0.582	2.025	0	101
Specialized farm hh (yes = 1)	0.427	0.495	0	1

where rural households' consumption is assumed to be influenced by their agricultural asset holdings $A_{h(t-1)}$. The use of lagged assets at $t-1$ is to mitigate the possible problem of endogeneity, as suggested by Dercon and Christiaensen (2011). s_{htj} represents all $j \in \{1, 2, \ldots, J\}$ kinds of shocks as described in the previous section and $\hat{\gamma}_{2j}$ is expected to be negative for unfavorable shocks as they may bring consumption shortfalls. Among various shocks, income shocks are of particular interest. $s_{ht}^{inc.}$ includes both idiosyncratic and covariate income shocks, while $s_{ht}^{iinc.}$ denotes idiosyncratic income shocks only. B_{htk} encompasses $k \in \{1, \ldots, K\}$ kinds of assets in Table 1; I_{ht} is another indicator variable equaling one if the household's kth asset B_{htk} is less than its median in each county at t. Households' wealth-differentiated coping capability when faced with income shocks is reflected by the interaction terms $\sum_{k=1}^{K} B_{h(t-1)k} s_{ht}^{inc.}$ where households' liquidity asset levels are proxied by $B_{h(t-1)k}$. Furthermore, $\sum_{k=1}^{K} B_{htk} s_{ht}^{inc.} I_{ht}$ helps indicate if those with few assets would be less capable of smoothing consumption.[24] Household characteristics are included in x_{ht}' controlling for the life-cycle effect. Household-specific time-invariant effects are represented by α_h.[25]

Besides describing consumption responses following shocks, Eq. (2) also allows us to simulate households' precautionary behavior as well as the counterfactual consumption levels under varied magnitudes of shock. That is, assuming different degrees of income shocks, we use the estimates of Eq. (2) including the error terms to simulate household per capita consumption. The coefficients of shock terms in Eq. (2) pick up the percentage consumption changes under some degrees of income shocks as opposed to the case without any income shocks, i.e., the effects of precautionary response to potential shocks according to Giles and Yoo (2007). As Giles and Yoo (2007), we multiplied the estimated coefficients of shock terms at a presumed income shock level, i.e.,

$$\sum_{j=1}^{J} \hat{\gamma}_{2j} s_{htj} + \sum_{k=1}^{K} \hat{\gamma}_{3k} B_{h(t-1)k} s_{ht}^{inc.} + \sum_{k=1}^{K} \hat{\gamma}_{4k} B_{htk} s_{ht}^{inc.} I_{ht}$$

[24] The choice of the median asset holdings to indicate those with limited assets ($I_{ht} = 1$) follows Dercon and Christiaensen's (2011) set-up. We also replaced the county median by the 25th and 75th percentiles of different asset holdings in each county and re-run Eq. (2), in order to check the sensitivity of the results. Under the asset threshold of 25th percentile, most estimators are similar to those under the county median (e.g., Table 4) in terms of both the magnitude and significance levels. The differences lie in the role of agricultural assets and housing in mitigating idiosyncratic income shocks: the insignificant estimators in Rows 3 and 5 in Table 4 become 0.222 and −0.416 at 10% significance level, respectively. Given the estimator for idiosyncratic income shocks is −0.101, this means that agricultural assets could help the least wealthy households offset completely negative covariate income shocks, while investment in housing would make them experience a further reduction in welfare in terms of household consumption. Under the threshold of 75th percentile, the beneficial impact of agricultural assets disappears. Investment in housing still causes further reduction to household consumption should negative idiosyncratic income shocks hit, but to a lesser extent — the estimator in Row 5 is −0.032 at 10% significance level as opposed to −0.416 under the 25th percentile. This implies a wealth effect on self-protection from shocks. Other estimators are similar to Table 4. Despite the above robustness checks, one may avoid completely an arbitrary split, but rather employ threshold estimation as Carter and Lybbert (2012) to locate exactly a "dynamic asset threshold" below which households are likely to slide backwards until they settle into asset-based poverty traps. This would lead to a second paper extending the present study.

[25] Both household fixed effects and the attempt of including more kinds of shocks than previous studies can help to mitigate the omitted variable problem in the consumption regression, while admittedly Eq. (2) is not immune to it.

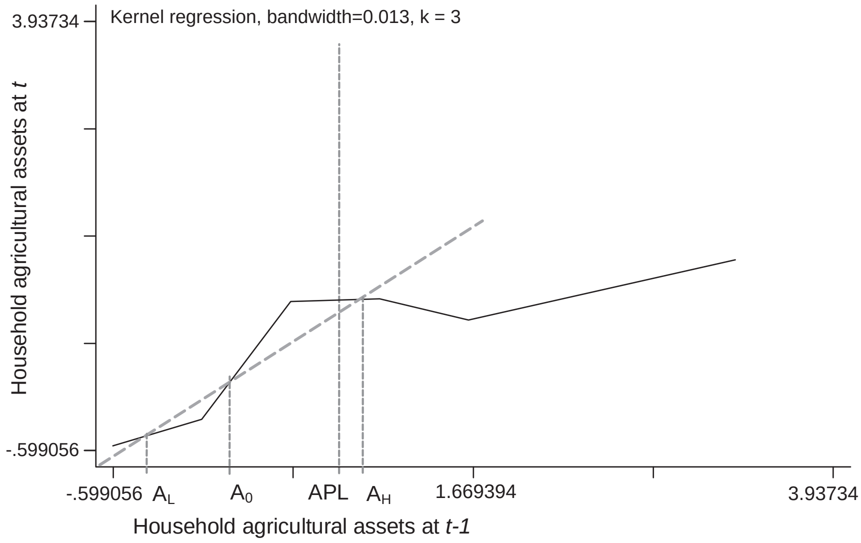

Fig. 2. Dynamics of agricultural assets, 1989–2006. Note: The finding of multiple equilibria is robust across different methods of smoothing and the numbers of grid points. The static asset poverty line, denoted by APL, is the asset level that could bring household income up to the monetary poverty line at US$1.25/day adjusted to the urban–rural price gap of 37% (as suggested by Ravallion & Chen, 2007). Following Barrett et al. (2006), we use a fixed-effects panel model to regress household agricultural assets on household net income and time-varying village effects. The APL is predicted by substituting the income poverty line in the regression. Source: Author's calculation based on data from the CHNS (1989–2006).

where the income shock variables were presumed to be at a certain level. The above term was then multiplied to households' observed per capita consumption, which yields households' per capita precautionary savings due to these presumed income shocks. By assuming different magnitudes of idiosyncratic and covariate income shocks (s_{htj} and $s_{ht}^{inc.}$), we can simulate precautionary savings due to idiosyncratic or covariate shocks only. Both precautionary savings and counterfactual consumption are proxies for potential downside risks and will be used in investigating households' risk mitigation behavior in the next sub-section.

4.2. Mitigating downside risks

The ex ante response to risk is described by the following accumulation decision-making. The annual growth rate of household agricultural assets (from t to $t+1$) is represented by a latent variable g_{ht}^{*}, and is determined by a number of factors as follows:

$$\begin{aligned} g_{ht}^{*} &= \beta_1 A_{h(t-1)} + \beta_2 c_{ht} + \beta_{12} c_{ht} \cdot A_{ht-1} + \beta_{23} c_{ht} \cdot m_{v(t-1)} + \beta_{123} c_{ht} \cdot \cdot A_{ht} \cdot I_{ht} \\ &+ \beta_4 p_{ht}^{iinc.} + \beta_{14} p_{ht}^{iinc.} \cdot A_{h(t-1)} + \beta_5 p_{ht}^{cinc.} + \beta_{15} p_{ht}^{cinc.} \cdot A_{h(t-1)} + \sum_{j=1}^{J} \beta_{6j} s_{htj} + x_{ht}^{'} \beta_7 + \alpha_h + \varepsilon_{ht} \end{aligned} \tag{3}$$

where $A_{h(t-1)}$ denotes households' agriculture asset holdings at $t-1$ as in Eq. (2), but here is considered as a proxy for the ex ante cost of agricultural production facing households at the time of making production decisions; c_{ht} is the counterfactual consumption depending on the degrees of income shocks; $m_{v(t-1)}$ denotes a village's out-migration network in terms of the proportion of temporary out-migrants relative to the village total population (Giles & Yoo, 2007) as a means of risk mitigation, given that households could invoke social networks to mitigate risk (Fafchamps, 2009) and for rural China migration is an increasingly important means to generate higher income and therefore helps rural households resist downside risk; $p_{ht}^{iinc.}$ and $p_{ht}^{cinc.}$ are simulated unproductive precautionary savings as the responses to idiosyncratic and covariate income shocks respectively; s_{htj} includes all other shocks specified in Eq. (2) except income shocks; $x_{ht}^{'}$ and α_h have the same definitions as before.

A negative $\hat{\beta}_1$ means that working capital constraints are binding in households' decision-making. Considering the fact that rural households could use their available agricultural assets for loans or liquidate assets in hard times, a negative coefficient also implies that more productive but riskier investments in agriculture are less likely to be disbursed if credit and liquidity constraints are tighter.

The present study distinguishes two kinds of potential risk from shocks drawing upon counterfactual simulations. On the one hand, following Dercon and Christiaensen (2011), the counterfactual consumption c_{ht}, based on various income shocks, indicates the potentially low welfare consequences if production were to fail. A positive coefficient $\hat{\beta}_2$ indicates households' reduced investment under "loss aversion".[26] On the other hand, we simulate precautionary savings $p_{ht}^{iinc.}$ and $p_{ht}^{cinc.}$ in response to

[26] See Dercon and Christiaensen (2011) for a theoretical model underlying this specification. They show that loss and risk aversion lowers consumption and therefore raises marginal utility. This in turn increases marginal productivity of risky inputs if the household aims to maximize income. Households' demand for risky inputs is therefore negatively affected by the high marginal utility which is proxied by the counterfactual consumption under shocks.

idiosyncratic and covariate income shocks, respectively. As discussed in Section 2.1, the household precautionary motive may also discourage productive investment, pointing to negative coefficients $\hat{\beta}_4$ and $\hat{\beta}_5$.[27]

To capture the ameliorating effect of out-migration networks, we interact c_{ht} with $m_{v(t-1)}$ and expect a positive estimate. In order to model wealth-differentiated risk-taking abilities (Foster & Rosenzweig, 2010), we multiply c_{ht}, $p_{ht}^{iinc.}$ and $p_{ht}^{cinc.}$ by agricultural assets at the time of decision-making. It might also be the case that asset growth for those with fewer assets than the median is more sensitive to exposure to risk. This is indicated by a negative coefficient $\hat{\beta}_{123}$ on $c_{ht} \cdot A_{ht} \cdot\cdot I_{ht}$.

We implement the following three methods to estimate Eq. (3). First, we follow Carter et al. (2007) and use a random-effects tobit model. The authors argue that the poorest households may be so poor that there is no room for further reduction of their asset holdings. In addition, Chinese farm households' limited range of crop varieties may be dictated by the grain procurement quota system (Yang, 2009) rather than by behavioral adjustments to risk. Both of these effects will bias the OLS estimates in Eq. (3) as they tend to capture “the inability of households in the lowest strata to liquidate assets” (Carter et al., 2007), rather than genuine risk-mitigating behavior. To make our estimates resistant to these potential biases, we adjust Eq. (3) to a tobit specification with random effects:

$$\begin{cases} g_{ht} = g_{ht}^* & \text{if } g_{ht}^* > 0 \\ g_{ht} = 0 & \text{if } g_{ht}^* \leq 0 \end{cases}. \tag{4}$$

By left-censoring the growth rates at zero, the estimates will be free of distortion.[28]

Second, we employ a fixed-effects tobit model. The possible correlation between household-specific effects α_h and other explanatory variables in Eq. (3) will give rise to spurious risk management behavior. Households sharing certain unobserved characteristics may suggest positive/negative asset growth rates, which can overshadow the genuine response to risk (see examples in Foster & Rosenzweig, 2010). To control for the unobservables, we follow Dercon and Christiaensen (2011) and adopt Honoré's (1992) semi-parametric approach to re-estimate the tobit model (Eqs. (3) and (4)) but with fixed effects.[29]

Third, although the tobit specifications can be used to examine the determinants of the magnitude of asset accumulation, they are powerless to find correlates of accumulation decisions. Thus, a conditional fixed-effects logit model, following Dercon and Christiaensen (2011) and Liverpool and Winter-Nelson (2010), is used to assess whether the explanatory variables in Eq. (3) alter households' production decisions. Controlling for fixed effects α_h, Eq. (3) is re-written as,

$$g_{ht} = \mathbf{1}\left(g_{ht}^* \geq 0\right). \tag{5}$$

The estimators are obtained by Chamberlain's (1980) conditional maximum likelihood method.[30]

It should be noted that one cannot directly interpret the magnitude of estimates in latent variable models (Greene, 2003). Therefore, in order to enrich the discussion and address household heterogeneity, we further define and calculate the household-specific marginal effects of each explanatory variable as the first-order derivative of the asset growth rate with respect to the explanatory variable of interest. That is, $\frac{\partial \Pr(g=1)}{\partial x_i} = F'(u)\beta_i$ where $F(u) = \frac{1}{1+\exp(-X\beta)}$ denotes the c.d.f. of the logistic distribution.[31]

5. Estimation results and discussion

5.1. Household wealth-differentiated risk-coping capability

5.1.1. Consumption responses to shocks

Table 4 reports estimation results of Eq. (2) and largely supports the hypothesis in Section 2.1. Agricultural asset holdings are insignificant, possibly because the asset variable $A_{h(t-1)}$ in the previous wave is actually the value 2–3 years ago. The impact of agricultural assets on consumption in the subsequent period may have disappeared.

---

[27] It could also be the case that withdrawing precautionary savings itself is an ex ante response to potential downside risks. However, as our focus is to study persistent poverty from the perspective of households' under-investment in asset accumulation, that is, whether and to what extent liquid assets in unproductive forms constitute a deterrent to households' future investment, the analysis (i.e., Eq. (3)) uses only the growth rate of asset accumulation as the dependent variable, but treats precautionary savings as independent variables and an ex post result of shocks.

[28] It might also be the case that some better-off households decide to smooth consumption by divesting their assets as this strategy is affordable for them. To check whether our conclusions are sensitive to this case, we also used a doubly tobit specification where Eq. (3) is not only left-censored at zero, but also right-censored at the 95th percentile of the growth rate of assets. The estimation results are broadly similar to those of the standard tobit (Eq. (3)) in Table 5.

[29] Honoré's (1992) estimator does not rely on parametric assumption for the distribution of the error terms, which is normal in conventional literature like Chamberlain (1980), nor parametric and linear relationship between households' fixed effects and the error terms as Chamberlain (1980). Alternatively, he simply assumes that ε_{t1} and ε_{t2}, in the case of $T = 2$, are independent and identically distributed conditional on (X_1,X_2,α) where X_1 and X_2 are the vectors including all independent variables for the individual in two periods, respectively. Then, the distribution of (g_1^*, g_2^*) is conditional on (X_1,X_2) and is symmetric around the 45-degree line through $(\Delta X\beta,0)$. Therefore, for a given individual, the estimator vector β is obtained through minimizing the moment conditions $\arg\min_b E[q(g_{i1}, g_{i2}, (X_{i1}-X_{i2}b))|g_{i1}>0, g_{i2}>0]$ where the absolute loss function takes the form $q(z_1,z_2,\delta) = z_1$ for $\delta \leq -z_2$; $|z_1 - z_2 - \delta|$ for $-z_2 < \delta < z_1$; and z_2 for $z_1 \leq \delta$.

[30] The conditional logit model actually nets out fixed effects in the estimation process. Given this shortcoming, we also apply OLS to a fixed-effects linear probability model as a robustness check. It makes the accumulation decisions directly dependent on household fixed effects, although still suffering some drawbacks (e.g., there are constant marginal effects and some households' predicted probabilities of asset accumulation may go beyond [0,1]). Results are broadly similar to those of the conditional logit model.

[31] A full list of formulae for the marginal effect of each explanatory variable will be furnished upon request.

Table 4
Household per capita consumption response to shocks.
Source: Author's calculation based on data from the CHNS (1989–2006).

Independent variables	(1)	(2)
1. Agricultural assets at $t-1$	−0.030 (0.025)	−0.030 (0.025)
Idiosyncratic shocks		
2. hh income shocks	0.007 (0.048)	0.003 (0.048)
3. hh income shock × initial agricultural assets at $t-1$	−0.017 (0.028)	−0.020 (0.028)
4. hh income shock × initial business assets at $t-1$	−0.013 (0.023)	−0.015 (0.023)
5. hh income shock × initial investment in housing at $t-1$	0.001 (0.010)	0.003 (0.010)
6. hh income shock × initial investment in consumer durables at $t-1$	−0.029 (0.016)*	−0.025 (0.016)
7. hh income shock × initial human capital at $t-1$	0.006 (0.004)	0.006 (0.004)
8. No. of ill members in last 4 weeks	0.064 (0.010)***	0.074 (0.011)***
9. No. of ill members in last 4 weeks × initial agricultural assets at $t-1$	0.022 (0.015)	0.019 (0.016)
10. No. of dead members	0.007 (0.023)	0.004 (0.023)
11. No. of dead members × initial agricultural assets at $t-1$	−0.020 (0.033)	−0.016 (0.033)
12. Whether have wedding, dowry or funeral expenditure	0.020 (0.014)	0.024 (0.015)
13. Whether have wedding, dowry or funeral expenditure × initial agricultural assets at $t-1$	0.014 (0.021)	0.019 (0.021)
14. hh income shock × agricultural assets × agricultural assets below median	0.343 (0.110)***	0.334 (0.110)***
15. hh income shock × business assets × business assets below median	−0.083 (0.076)	−0.079 (0.077)
16. hh income shock × investment in housing × invt. in housing below median	−0.027 (0.022)	−0.030 (0.022)
17. hh income shock × investment in consumer durables × invt. in consumer durables below median	0.013 (0.024)	0.014 (0.025)
18. hh income shock × human capital × human capital below median	0.004 (0.005)	0.003 (0.005)
Covariate shocks		
19. Income shock at the county level	−0.104 (0.056)*	−0.042 (0.058)
20. Income shock at the county level × initial agricultural assets at $t-1$	0.031 (0.040)	0.021 (0.041)
21. Income shock at the county level × initial business assets at $t-1$	−0.031 (0.019)*	−0.038 (0.019)**
22. Income shock at the county level × initial investment in housing at $t-1$	0.011 (0.008)	0.006 (0.008)
23. Income shock at the county level × initial investment in consumer durables at $t-1$	−0.012 (0.014)	−0.013 (0.014)
24. Income shock at the county level × initial human capital at $t-1$	−0.009 (0.005)*	−0.009 (0.005)*
25. Price shock of agricultural input at $t-1$ within the province		−0.994 (0.214)***
26. Price shock of agricultural output at $t-1$ within the province		0.399 (0.151)***
27. % sown land affected by natural disasters within the province		−0.598 (0.126)***
Demographic characteristics		
28. hh size	−0.089 (0.005)***	−0.088 (0.006)***
29. Age of hh head	0.023 (0.001)***	0.019 (0.001)***
30. Years of education of hh head	0.025 (0.004)***	0.019 (0.004)***
31. % male adults	0.204 (0.025)***	0.203 (0.025)***
32. Dependency ratio	−0.019 (0.026)	−0.018 (0.027)
Labor market access		
33. % local off-farm employment	0.065 (0.022)***	0.062 (0.022)***
34. Village out-migration networks		0.256 (0.175)
No. of observations	6931	6714
F-test of all $\alpha_h = 0$ (p-value)	0.000	0.000
R^2	0.176	0.177

Note: ***, ** and * denote 1%, 5% and 10% significance levels respectively. Standard errors are in parentheses.

Idiosyncratic income shocks (Row 2) are insignificant, which may be because wealthier households can more readily protect themselves against idiosyncratic income shocks. As suggested by statistically significant estimate in Row 14, the hypothesis of full risk-sharing against idiosyncratic income shocks is rejected for the asset-poor whose agricultural asset holdings are in the lower half of the agricultural asset distribution. Their consumption would rather decrease (increase) by a further amount when receiving the same negative (positive) income shocks compared to those in the upper half of the agricultural asset distribution.

The consumption for those possessing more durable goods is less sensitive to idiosyncratic income shocks (Row 6). Given the positive relation between consumer durables and household total wealth found by Park and Ren (2001), this lends support to the above argument that wealthier households are better able to smooth consumption when experiencing equivalent negative income shocks. Agricultural assets appear to be particularly crucial for households in coping with negative idiosyncratic income shocks (Row 14). Imai and You (forthcoming) also find that agricultural asset holdings help prevent rural households from backsliding into poverty, while running household businesses cannot. The asset-poor whose agricultural asset holdings are below the median would suffer further consumption shortfalls under the same degrees of negative idiosyncratic income shocks. Among other household-specific events, only illness significantly increases expenditure (Rows 8–13), which is predictable given long absence of health and medical insurance for rural households in the sample period.

Different from idiosyncratic income shocks, aggregated income shocks bring substantial consumption shortfalls (Row 19): 1% increase in the share of households earning less than before within the county can decrease the household consumption per capita by 10.4%. In contrast to the case of idiosyncratic shocks, agricultural assets cannot help households resist this hardship, as indicated by the statistically insignificant interaction term in Row 20. This is possibly because returns of agricultural production are not large enough to enable households to cope with potentially large income shortfalls.[32] Significantly negative coefficients of interaction terms between aggregated income shocks and business assets (Row 21) and human capital (Row 24) suggest that those with more business assets and human capital tend to undergo a greater decrease in consumption. This may be partly due to the fact that households with more human capital are engaged in more businesses that may suffer during an economic recession. Another reason may be that these households can afford to cut more consumption in the short-term in order to maintain their longer-term production.[33]

Consistent with past studies (e.g., Minten & Barrett, 2008), poorly functioning markets represented by agricultural input and output price shocks (Rows 25–26) have substantial impact on household consumption with predictable signs. They even dominate the effect of covariate income shocks, as the coefficient of the latter becomes insignificant in Column (2). Weather shocks (Row 27) also substantially reduce consumption; more importantly, their negative effects could continue for 3 to 4 years. To see this, following Dercon (2004), we replaced the variable of natural disasters at t with those which occurred several years previously. The coefficient declines marginally to -0.27, indicating that a short-lived shock is likely to influence households' welfare in at least the medium-term.

5.1.2. Precautionary motives

Reserving precautionary savings as a coping means for negative shocks is examined by using Column (1) of Table 4 to simulate per capita unproductive precautionary savings under various idiosyncratic and covariate income shocks. Meanwhile, households' observed per capita savings are derived by subtracting per capita consumption from per capita income. As shown in Fig. 3, the ratio of per capita precautionary savings over per capita total savings measures the households' precautionary motives.

In general, the results reaffirm Jalan and Ravallion's (2001) finding of an inverted-U relationship between households' wealth, which is represented by their per capita permanent income, and per capita unproductive precautionary savings. Under all three levels of idiosyncratic income shocks, the share of precautionary savings in households' total savings increases from the 1st to the 3rd quintile but decreases as households become much richer. Experiencing equal degrees of negative shock, poorer households tend to hold relatively more savings in unproductive forms while wealthier households may not need to do so. Similar behavior can also be found when covariate income shocks occur, while the magnitude of precautionary motives becomes greater compared with the case of idiosyncratic income shock.[34]

Furthermore, the monetary values of precautionary savings are also quantitatively meaningful (Giles & Yoo, 2007). For example, the net profit in 2005 for grain crops per *mu* was 124.4 *yuan*.[35] This means that if 25% of population within the county experienced income shortfalls (i.e., 0.25 covariate income shocks) an average household would preserve 432.6 *yuan* as precautionary savings, which is equivalent to the net profits from 4 out of the 14 *mu* of cultivated land it owns. Strong precautionary motives clearly bring about inefficient resource allocation.

5.2. Household wealth-differentiated risk-mitigating capability

Table 5 reports households' ex ante risk management.[36] In the spirit of Dercon and Christiaensen (2011), we calibrate three risk cases. Case (a) assumes that every household receives the 25th percentile of a negative idiosyncratic income shock and 0.25 aggregated income shock in each year. Case (b) simply employs the empirical distribution of idiosyncratic and aggregated income shocks. Case (c) also makes use of the empirical distribution of income shocks but in order to emphasize the downside risk, the observed idiosyncratic income shocks are right-truncated at the median of all negative ones. That is, all idiosyncratic income shocks above this median take the value of zero. Similarly, the covariate income shocks are also right-truncated at their median.[37]

Based on these three cases, we draw upon counterfactual simulations to obtain two kinds of downside risk: low consumption outcomes and substantially unproductive precautionary savings. The risk of low welfare consequences is measured by predicted counterfactual log per capita consumption under the presumed income risk in Case (a) and predicted probability-weighted mean log per capita consumption in Cases (b) and (c). The risk of inefficient resource allocation is indicated by predicted log per capita unproductive precautionary savings as responses to relevant idiosyncratic and covariate income shocks in three cases. Using

[32] We estimated the returns of agricultural assets by regressing the log of household farm income on the household's agricultural asset holdings and the household fixed effects. The predicted marginal return of agricultural asset accumulation on household farm income is only 1%.

[33] We compared households' real consumption between those with more and less human capital (business assets) than the median in each year. The former group's consumption is on average 46% (12%) higher relative to the latter. Thus, it seems safe to argue here that households with more human capital and business assets are more capable of sacrificing some of their consumption to sustain production. As a result, real per capita permanent income for those possessing more human capital (business assets) than the median is 27% (6%) higher than that of those below the median.

[34] Our simulation of precautionary savings should be treated as a lower bound of the real value as it does not consider the impact of households' concern over limited access to credits. In fact, Lee and Swada (2010) find that, in the case of rural Pakistan, the strong motive for precautionary savings is also tied to household liquidity constraints. Taking this into account, households' real precautionary motives might be stronger than our calculations.

[35] *Mu* is the Chinese measurement unit for land, 1 *mu* $\approx$ 666.67 m^2. This figure is the national average value in 2006 prices and comes from the author's calculations based on data in China Agricultural Yearbook (2006) and China Statistical Yearbook (2009).

[36] We do not include price shocks, natural disasters, illness, death and weddings, because strictly speaking, they are *shocks* rather than potential *risks*. However, including them in the estimation does not fundamentally change our conclusions.

[37] To check sensitivity of the results to the selection of three typical Cases (a) to (c), I repeated all calculations for additional scenarios as follows: (1) holding relatively low idiosyncratic income shocks at the 25th percentile, setting the aggregated income shocks at 0.5 and 0.75, respectively (the case of 0.25 has already been shown as Case (a)); (2) holding idiosyncratic income shocks at the median level (i.e., the 50th percentile), setting the aggregated income shocks at 0.25, 0.5 and 0.75, respectively; and (3) holding relatively high idiosyncratic income shocks at the 75th percentile, setting the aggregated income shocks at 0.25, 0.5 and 0.75, respectively. The main conclusions still hold.

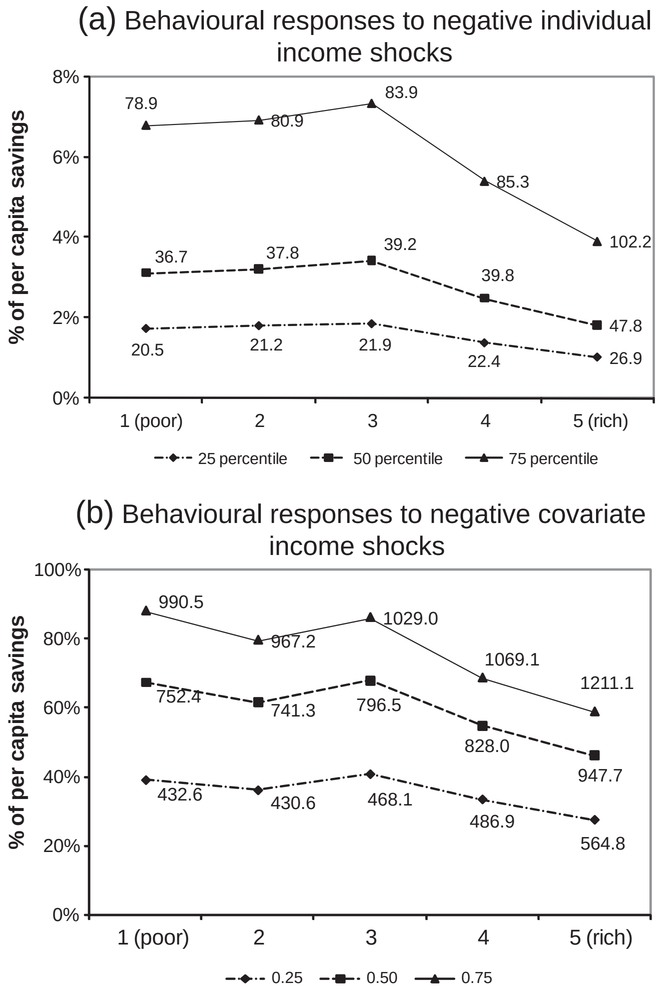

Fig. 3. Simulated households' per capita unproductive precautionary savings in response to income shocks (by quintile). (a) Behavioral responses to negative individual income shocks. (b) Behavioral responses to negative covariate income shocks. Note: a. The dots denote proportions of per capita precautionary savings in total per capita savings for each income quintile. The figures along the lines are absolute values of precautionary savings in 2006 prices. b. Quintiles are based on households' per capita permanent income and sorted in ascending sequence. Source: Author's calculation based on data from the CHNS (1989–2006).

predicted values in the above simulations helps to obviate measurement errors in consumption and avoid the use of instruments, so that "the fundamental identification problem in assessing the impact of consumption risk on production decisions is circumvented" (Dercon & Christiaensen, 2011, p. 166). We proceed by discussing specific correlates in Table 5.

5.2.1. Working-capital related credit and liquidity constraints

The coefficient of agricultural assets at $t-1$ ($\hat{\beta}_1$) is significantly negative in all cases. This indicates that facing more ex ante costs of agricultural production, households would be less willing to invest in the subsequent period.[38] Since we cannot multiply it by available credits to the household, the estimate should be treated as an upper bound of working-capital related credit and liquidity constraints.

The binding credit and liquidity constraints in rural China are also supported by the existing literature. From the supply side, rural households have access to limited amounts and types of both formal financial credit (Dong & Featherstone, 2006) and formal and informal consumption insurance (Giles, 2006). In 10 representative provinces, 71% of rural households face credit constraints (Rui & Xi, 2010). Even when limited formal financial credits are available, they lack efficiencies and incur risk (Dong & Featherstone, 2006). Although some households may obtain informal loans, they are mainly used to cope with unexpected shocks rather than productive investment (de Brauw & Rozelle, 2008). From the demand side, in the period of 1985–2006, on average 78% of household expenditure on production takes the form of cash,[39] but agricultural assets are neither as easy nor as efficient to

[38] We also estimate the fixed-effects models without left-censoring. The coefficients are insignificant in all three cases. This finding rejects the conditional convergence of agricultural assets and is consistent with multi-equilibrium dynamics illustrated in Fig. 2.

[39] Author's calculation based on data from China Statistical Yearbook (2009) and China Agricultural Development Report (2007).

liquidate as might be thought.[40] In sum, the greater working-capital related credit and liquidity constraints, the less investment in agricultural asset accumulation would a household undertake in the future.

It is noticeable that the magnitude of $\hat{\beta}_1$ varies across the three cases.[41] When more weight is given to downside (aggregated) risk (Case (b)), households are more reluctant to increase accumulation. Nevertheless, so far as much greater negative income shocks are concerned (Case (c)), households' accumulation decisions are less likely to be influenced than in Case (b). The reason might be that households have to protect the fewer assets on which their minimum livelihood depends when extremely hard times are expected. We will discuss this further in the following paragraphs.

5.2.2. The risk of low consumption outcomes

The significantly positive coefficient of counterfactual consumption in Case (a) implies that when negative income shocks are anticipated, the lower the counterfactual consumption level (i.e., higher risk of low consumption outcomes), the less would households invest in agricultural asset accumulation. By contrast, when more weight is assigned to downside risk in Cases (b) and (c), the coefficients become significantly negative, indicating that households are more inclined to accumulate when facing greater risk of low welfare.

The existing literature offers two possible reasons for the above seemingly contradictory estimates of the coefficient of counterfactual consumption. One reason that has been identified (in rural Zimbabwe in Hoddinott, 2006; northern Kenya in Barrett et al., 2006; Ethiopia and Honduras in Carter et al., 2007; and theoretically in Zimmerman & Carter, 2003) is that the poorest households have to safeguard limited productive assets on which their subsistence depends. The other explanation offered refers to a two-way effect between wealth dynamics and risk-taking behavior. Lybbert and Barrett (2011) show that there is a reverse effect of a dynamic asset threshold on household risk-taking behavior. They find that those at, or slightly above, the asset bifurcation level may face a greater probability of getting trapped in low equilibrium under risk should income losses occur. Therefore, perceiving this impending danger of backsliding, these not-so-poor households may prefer a conservative investment strategy.[42]

Our data lend support to both explanations. As Barrett et al. (2006), we computed coefficients of variation in income and consumption. The overall pattern of risk management drawn from Fig. 4 is that wealthier households smooth consumption more effectively and undertake more risky production than poorer households.[43] However, on the one hand, the poorest 12.5% has larger consumption variability compared with income, implying asset smoothing at the cost of variable consumption particularly in consumer durables, medical and insurance expenditures, but rarely food.[44] They are unwilling to stake survival as it is at least better than starvation (Fafchamps, 2003). On the other hand, income volatility for those lying between the 30th and 40th percentile of asset distribution decreases as households become wealthier, while consumption volatility increases. This movement suggests that the not-so-poor who are perhaps near the bifurcation point might be asset smoothers rather than consumption smoothers.[45] A household's position in the wealth distribution could also influence its risk-taking behavior.

It should be noted that the asset-defending behavior for some households by no means assures them of a leap to a high equilibrium because of the structure of household expenditure. Apart from spending on production, in the period 1995–2006, more than 60% of rural household expenditure is used for living and over half of the living expenditure goes on food.[46] This

[40] One reason lies in limited channels of liquidation. A more important reason could be that if many households sell productive assets under shocks, the prices would decrease so that the returns would be insufficient to cope with shocks (Dercon, 1998).

[41] The coefficients of agricultural assets at $t-1$ ($\hat{\beta}_1$) and risk of low welfare outcomes measured by counterfactual consumption ($\hat{\beta}_2$) in Column (4) seem to be very different from those of Columns (5) and (6) within Case (b). It is worth noting that coefficients in the tobit model pick up not only the probability but also the magnitude effect of an increase in the independent variable on accumulation, while those in the logit model only capture the former. Specifically, larger coefficients in the logit model (Column 4) than in the tobit set-up (Columns 5–6) may be because working-capital constraints and relatively large downside (aggregated) risks discourage households' asset accumulation by reducing the probability of undertaking investment more than by reducing the magnitude of the growth rate of investment. This could be supported by applying McDonald and Moffitt's (1980) decomposition to the random-effects tobit model (Column 6) and calculating the marginal effects in the logit specification (Column 4). In the tobit specification, the total change in the unconditional expected value of g^* can be decomposed into: (1) the change in the expected value of g^* of those above zero (i.e., those undertaking accumulation), weighted by the probability of being above zero; and (2) the change in the probability of being above zero, weighted by the conditional expected value of g^*. In the logit specification, I calculated the marginal effects of independent variables on the probability of undertaking accumulation. Therefore, component (2) in tobit can be compared with the estimated coefficients in the logit specification since both mean how the change in the independent variable affects the probability of accumulation. I found that the probability-decreasing effect (2) is 26% (29%) and the effect on the probability of accumulation in the logit model is 37% (32%) for every marginal increase in working-capital constraints (the risk of low consumption outcomes). The differences in the marginal effects on undertaking accumulation between tobit and logit models are not as large as the magnitude of the estimated coefficients.

[42] Different degrees of risk (measured by the level of counterfactual consumption) faced with households under different presumed risk distributions may also matter. The changing sign of the estimated coefficient of counterfactual consumption across three cases may indicate that households prefer to safeguard their assets when the potential risk of failure in investment plans is relatively small (Case (a)), but are willing to smooth assets and switch to smoothing consumption when faced with greater downside risks attached to future investment plans (Cases (b) and (c)).

[43] It is worth noting that those in the 7th and 8th deciles experienced more volatile consumption than poorer households. This is driven mainly by higher volatility in consumption expenditure on consumer durables: the average volatility of consumer durables of these two deciles is 115% higher than that of the poorest decile, while the average volatilities of food consumption and medical and health insurance expenditure are 33% and 25% lower than those of the poorest decile, respectively.

[44] For the lowest decile, the coefficients of variation of per capita expenditure on medical and health insurance and consumer durables are 8 and 3 times as high as that of per capita total consumption expenditure. By comparison, the coefficient of variation of food consumption is basically the same as that of per capita total consumption expenditure.

[45] In Fig. 4, the richest 10% of households also appear to be asset smoothers as their income volatility decreases and consumption volatility increases. However, they are less relevant here, considering that their consumption will not easily fall below the poverty line.

[46] Author's calculation based on data from China Statistical Yearbook (2009) and China Agricultural Development Report (2007).

Table 5
The correlates of agricultural asset growth.
Source: Author's calculation based on data from the CHNS (1989–2006).

Independent variables	Case (a) The 25th percentile negative hh idiosyncratic income shock			Case (b) Probability weighted (without truncation)			Case (c) Probability weighted (with truncation)		
	Cond. FE Logit (1)	Honoré FE Tobit (2)	Std. RE Tobit (3)	Cond. FE Logit (4)	Honoré FE Tobit (5)	Std. RE Tobit (6)	Cond. FE Logit (7)	Honoré FE Tobit (8)	Std. RE Tobit (9)
1. hh agricultural assets at $t-1$	−2.054 (0.561)***	−0.146 (0.046)***	−0.340 (0.164)**	−50.921 (6.910)***	−1.239 (0.684)*	−15.232 (2.403)***	−1.838 (0.292)***	−0.146 (0.039)***	−0.466 (0.098)***
2. ln(per capita counterfactual cons.)	1.754 (0.809)**	0.143 (0.048)***	−0.023 (0.054)	−24.675 (4.066)***	−1.460 (0.277)***	−0.175 (0.064)***	−0.152 (0.061)**	−0.011 (0.004)***	−0.032 (0.021)
3. ln(per capita counterfactual cons.) × % village out-mig. at $t-1$	2.120 (1.044)**	0.065 (0.069)	0.615 (0.330)*	0.781 (1.182)	0.060 (0.061)	−0.017 (0.376)	−3.787 (3.323)	−0.110 (0.261)	−1.911 (1.192)
4. ln(per capita counterfactual cons.) × agri. assets at $t-1$	0.226 (0.223)	−0.016 (0.022)	−0.017 (0.064)	20.312 (2.850)***	0.462 (0.293)	6.121 (0.990)***	0.045 (0.072)	0.004 (0.007)	0.011 (0.026)
5. ln(per capita counterfactual cons.) × agri. assets × agri. assets below median	−1.293 (0.165)***	−0.072 (0.008)***	−0.271 (0.045)***	−1.273 (0.172)***	−0.071 (0.010)***	−0.292 (0.049)***	−1.061 (0.326)***	−0.069 (0.013)***	−0.311 (0.109)***
6. ln(per capita precautionary savings responding to hh inc. shocks)	−0.174 (0.044)***	−0.007 (0.003)	−0.042 (0.012)***	−0.039 (0.042)	0.003 (0.002)	0.020 (0.014)	−0.126 (0.033)***	−0.0004 (0.002)	−0.011 (0.012)
7. ln(per capita precautionary savings responding to hh inc. shocks) × agri. assets at $t-1$	0.439 (0.054)***	0.012 (0.006)**	0.121 (0.018)***	0.238 (0.054)***	0.013 (0.006)**	0.064 (0.020)***	0.186 (0.044)***	0.017 (0.005)***	0.060 (0.018)***
8. ln(per capita precautionary savings responding to covariate income shocks)	−0.179 (0.101)*	−0.006 (0.006)	−0.086 (0.025)***	−0.189 (0.112)	−0.008 (0.007)	−0.126 (0.028)***	−0.359 (0.097)***	−0.018 (0.009)**	−0.165 (0.023)***
9. ln(per capita precautionary savings responding to covariate inc. shocks) × agri. assets at $t-1$	0.157 (0.099)	0.032 (0.011)***	0.042 (0.032)	0.288 (0.110)***	0.037 (0.014)**	0.052 (0.036)	0.547 (0.087)***	0.045 (0.012)***	0.140 (0.030)***
10. hh size	0.229 (0.083)***	0.017 (0.005)***	0.004 (0.010)	0.090 (0.052)*	0.004 (0.003)	0.028 (0.011)***	0.153 (0.046)***	0.009 (0.003)***	0.020 (0.010)**
11. Age of hh head	−0.085 (0.021)***	−0.007 (0.001)***	−0.004 (0.001)***	−0.013 (0.014)	−0.001 (0.001)	−0.004 (0.002)**	−0.058 (0.010)***	−0.005 (0.001)***	−0.005 (0.001)***
12. Years of education of hh head	−0.126 (0.039)***	−0.012 (0.003)***	−0.005 (0.005)	−0.008 (0.044)	−0.001 (0.003)	−0.005 (0.005)	−0.087 (0.036)**	−0.008 (0.003)***	−0.003 (0.005)
13. % male adults	−0.004 (0.249)	−0.011 (0.014)	0.110 (0.046)**	0.348 (0.223)	0.015 (0.016)	0.142 (0.053)***	0.388 (0.198)**	0.019 (0.013)	0.057 (0.048)
14. Dependency ratio	−0.143 (0.209)	−0.010 (0.012)	−0.024 (0.056)	−0.419 (0.258)	−0.026 (0.015)*	−0.033 (0.066)	−0.312 (0.219)	−0.019 (0.015)	0.032 (0.063)
15. % local off-farm employment	0.387 (0.173)**	−0.005 (0.009)	0.248 (0.050)***	−0.114 (0.213)	−0.025 (0.013)*	0.312 (0.058)***	0.304 (0.169)*	0.010 (0.009)	0.241 (0.052)***
16. Whether a specialized farm hh (yes = 1)	0.458 (0.103)***	0.034 (0.006)***	0.168 (0.032)***	−0.053 (0.128)	0.002 (0.008)	0.155 (0.035)***	0.200 (0.097)**	0.020 (0.006)***	0.080 (0.032)**
17. Land-on farm labor ratio	−0.064 (0.033)*	−0.002 (0.002)	−0.028 (0.010)***	−0.013 (0.034)	0.0002 (0.001)	−0.019 (0.012)	−0.004 (0.030)	0.001 (0.003)	−0.015 (0.012)
Pseudo R^2	0.208			0.209			0.132		
Prob. > χ^2		0.00	0.00		0.00	0.00		0.00	0.00

Note: a. In the fixed-effects tobit model, the objective function is minimized by estimators taking the form of the absolute error loss in Honoré (1992).
b. Standard errors are in parentheses and those for Honoré's (1992) fixed-effects probit models are estimated by 300 bootstraps.
c. ***, ** and * denote 1%, 5% and 10% significance levels respectively.

implies rigidity in further sacrificing consumption to support production. Therefore, facing possible low-equilibrium traps, the foregone consumption is more of a short-term palliative in favor of preserving crucial assets than a long-term feasible means of escape from poverty.

As with factors dampening households' fear of the risk of low welfare outcomes, the positive estimate of $c_{ht} \cdot m_{v(t-1)}$ indicates that out-migration alleviates households' fear of the risk of negative shocks in agricultural production and, therefore, encourages them to pursue more profitable and riskier investment plans.[47] Total marginal effects in Fig. 5 further illustrate that all households' accumulation can benefit from out-migration in Case (a), though they face the threat of low consumption outcomes. The pattern suggested by the quadratic fitted line is that the more village out-migration, the more likely households would undertake accumulation. An additional 10% of village-level out-migration could on average double the probability of asset accumulation. However, if more downside risk is likely to occur as Cases (b) and (c), the benefit of out-migration disappears as its estimated coefficients become statistically insignificant.

[47] We also discovered whether out-migration networks help with mitigating weather and price risks by including interactions between the village share out-migration at $t-1$ and the sown areas affected by natural disasters and the price shocks of agricultural input and output. Out-migration can counter the impact of price risk in Case (a) and mitigate weather risk in the other two.

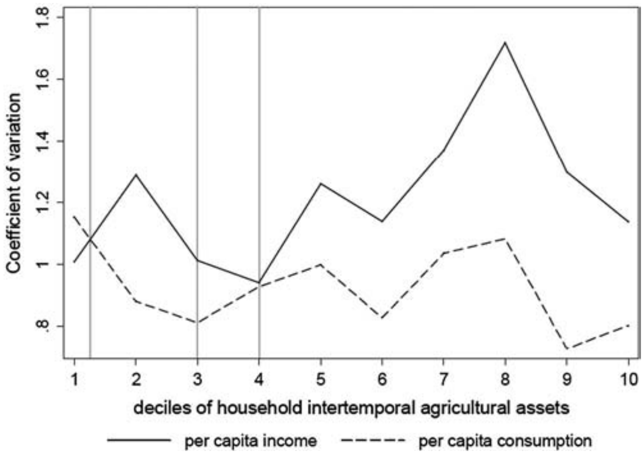

Fig. 4. Wealth-differentiated risk management, 1989–2006. Note: The variances were calculated across time: I calculated the coefficients of variation for each household's per capita income and consumption over the period 1989–2006, respectively. Households are lined ascendingly at the horizontal axis according to their intertemporal agricultural asset holdings over the period 1989–2006. Source: Author's calculation based on data from the CHNS (1989–2006).

The other ameliorating factor appears to be the assets already in the household's possession i.e., the wealth effect. Positive estimates of $c_{ht} \cdot A_{h(t-1)}$ imply that when perceiving the same degrees of downside risk in consumption outcomes, those having more assets in hand would be more willing to undertake accumulation in the future. One might also notice that, as mentioned before, assets in hand at the time of decision-making could also proxy for the ex ante working-capital constraints directly restricting households' accumulation in the subsequent production period. It is thus necessary to investigate further the "net" influence of agricultural asset holdings on the chance of accumulation in the future by calculating the total marginal effect of $A_{h(t-1)}$ as $\frac{\partial \Pr(g=1)}{\partial A} = \left(\beta_1 + \beta_{12}c_{ht} + \beta_{123}c_{ht}I_{ht} + \beta_{14}p_{ht}^{iinc.} + \beta_{15}p_{ht}^{cinc.}\right)F^{'}(u)$. The quadratic fitted line in Fig. 6 shows that the more the asset holdings, the higher the probability of undertaking accumulation. In other words, the wealth effect dominates. However, there is also apparent heterogeneity across households. Many of those at the bottom of asset distribution, who are more likely to face working-capital related credit constraints and find difficulties in obtaining loans, suffer from substantially negative total marginal effects of assets than their wealthier counterparts. This also implies that once taking the credit and liquidity constraints into account, only wealthier households appear to enjoy the benefit of asset holdings for cushioning the negative influence of low consumption outcomes. By contrast, the asset-poor are less likely to enjoy the risk-resisting effect of agricultural asset holdings, but have to struggle with advancing the money before the production plan is carried out. In sum, the working-capital related credit and liquidity constraints appear to be the main obstacle for asset accumulation and could even countervail the self-insurance function of asset holdings against the downside risk. In Cases (b) and (c), unlike out-migration, agricultural asset holdings still serve as a statistically significant means to mitigate risk. However, its effectiveness is weaker given much smaller magnitude of marginal effects for every household compared to Fig. 6.

The above conclusion could be seen more clearly by the trivariate interaction term $c_{ht} \cdot A_{h(t-1)} \cdot I_{ht}$. Owning less assets than the median ($I_{ht} = 1$) does, in all cases, significantly reduce the probability that households will decide to accumulate (Row 5). By calculating the marginal impact of $I_{ht} = 1$ on the accumulation-enhancing effect of household asset holdings ($\frac{\Delta\left(\frac{\partial^2 \Pr(g=1)}{\partial c \partial A}\right)}{\Delta I}$), we find that all trivariate interaction effects are negative, indicating that, at the same level of downside consumption risk, less agricultural asset than the median weakens the positive effect of asset holdings on households' investment incentives which has been revealed by $c_{ht} \cdot A_{h(t-1)}$. The smaller the assets, the greater this negative influence would be. On average, the effectiveness of asset holdings at the time of decision-making in encouraging subsequent accumulation (i.e., the interaction effect $c_{ht} \cdot A_{h(t-1)}$) would be blunted by a half if the household falls in the bottom half of asset distribution.

5.2.3. Risk of substantially unproductive precautionary savings

Our analysis documents an "implied risk premium for self-insurance strategies" in risk mitigation (Barnett et al., 2008). Holding precautionary savings as a self-insurance strategy should idiosyncratic and/or covariate income shocks occur is at the cost of higher expected income, namely reduced investment in agricultural asset accumulation (Rows 6 and 8).[48] That said agricultural asset holdings could counteract the real costs of precautionary motives on profitable investment. The positive estimated interaction terms $p_{ht}^{iinc.} \cdot A_{h(t-1)}$ and $p_{ht}^{cinc.} \cdot A_{h(t-1)}$ (Rows 7 and 9) imply that the asset-poor (rich) are less (more) likely to invest in the presence of when facing the same level of income shocks. After taking the buffering role of asset holdings into account, we look at the overall marginal effect of precautionary savings as a response to idiosyncratic income shocks on

[48] The real negative impact of strong precautionary motives might be more than that revealed by our estimates because rural households are likely to have greater prudence when faced with liquidity constraints (Lee & Swada, 2010).

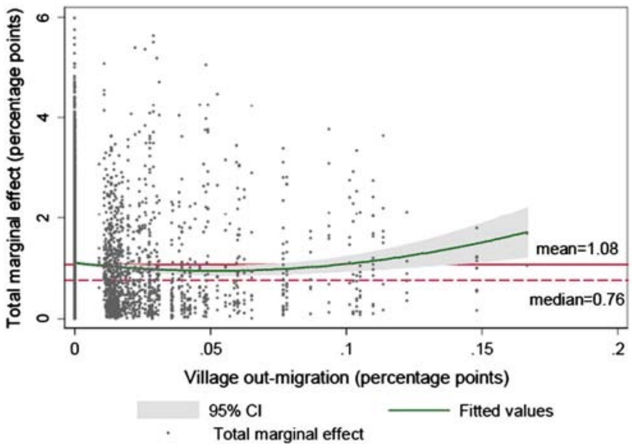

Fig. 5. Total marginal effects of village out-migration on the probability of asset accumulation. Source: Author's calculation based on data from the CHNS (1989–2006).

accumulation (Fig. 7a). Positive total marginal effects for some households, who are mostly likely the wealthier, mean that they are able to undertake accumulation in the future, although withdrawing substantial precautionary savings spawns inefficient resource allocation. When holding precautionary savings under 0.25 covariate income shocks (Fig. 7b), however, all households become less prone to accumulation irrespective of their position in the asset distribution. This suggests that in the absence of well-functioning capital markets and formal insurance contracts, households hardly self-insure against large scale shocks by simply appealing to their asset holdings, but have to trade-off their expected future income. In Cases (b) and (c), no household can resist greater downside income risk, even for the wealthier: the marginal effects of precautionary savings in response to both idiosyncratic and covariate income risk turn to be negative for all households with larger magnitude (in absolute terms) compared to Case (a).

5.2.4. Other factors facilitating accumulation

Local off-farm employment is positively related to asset growth in most of the regressions (Row 15). In Case (a), its marginal effects are positive for all households and increases as more household members have off-farm jobs. On average, an extra 10% of off-farm employment raises the probability of accumulation by 7.1%, while this positive effect almost disappears in Cases (b) and (c) where more weights are put to the negative income risk.

Specialized farm households (those whose farm sizes are more than 20 *mu*[49]) are more likely to invest in agricultural assets (Row 16) as a larger farm size may allow households to diversify into different crops, which could help them to resist the potential production risk. However, this mechanism seems not to work well when more downside risk is anticipated given that the estimated coefficients become insignificant in Cases (b) and (c).

A higher land-(on farm) labor ratio relates significantly and negatively to incentives to accumulate in Case (a) but prefer to use agricultural labor, as far as comparative advantage of agricultural labor is concerned (Dercon & Christiaensen, 2011). Nevertheless, this choice is unequally distributed across households when we look at the marginal effect for each household, and disappears in Cases (b) and (c).

6. Conclusion

This paper provides new insight into the causes of persistently low income in rural China by examining the impact of risk on households' investment in agricultural assets that are crucial for them to make a better living. Households' ex post coping strategies and ex ante risk management make them conservative in accumulating more profitable but riskier agricultural assets. Together with multiple equilibria in agricultural asset dynamics, our answer to the research question raised in Section 1 is to confirm that risk can trigger dynamic asset poverty in rural China. It causes under-investment in profitable agricultural asset accumulation through the above two behavioral responses, which gives rise to prolonged hardship. We make two further points below indicating policy implications based on these findings.

First, it is important to establish productive safety nets to promote households' self-reinforcing growth by asset accumulation through steady investment. Safety net policy should not only consider the magnitude of adverse shocks, but also pay attention to households' asset position after a shock, and their risk management, in order to protect households from downward mobility (Elbers et al., 2007). Specifically, it would therefore seem to be desirable to provide more formal financial credit, loans and

[49] Although farm land is distributed by governments according to family size in rural China, some households "chose to rent their land, negotiating share-cropping arrangements or lending their land to kinsmen or neighbors who agreed to assume responsibility for the contract grain quota" (de Janvry, Sadoulet, & Zhu, 2005, p. 5). This allows some households to participate in more non-farm activities, while others specialize in farming.

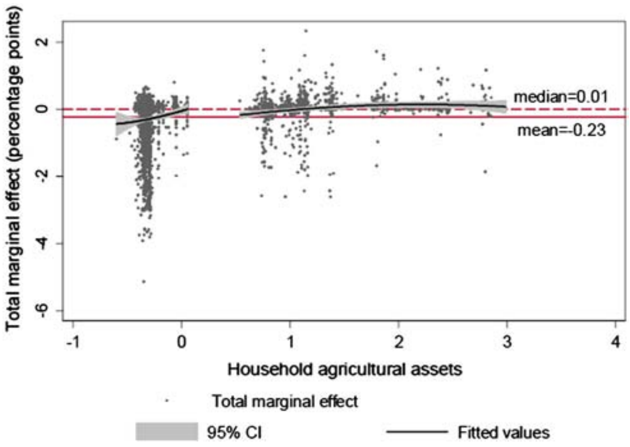

Fig. 6. Total marginal effects of agricultural assets on the probability of asset accumulation. Source: Author's calculation based on data from the CHNS (1989–2006).

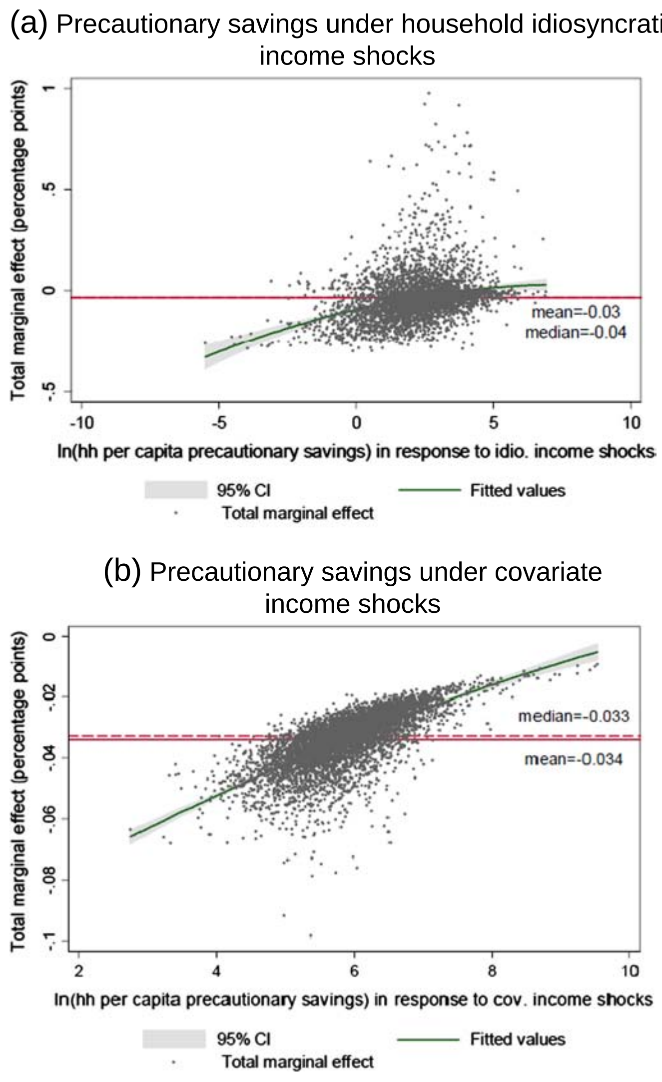

Fig. 7. Total marginal effects of precautionary savings on the probability of asset accumulation. Precautionary savings under household idiosyncratic income shocks. Precautionary savings under covariate income shocks. Source: Author's calculation based on data from the CHNS (1989–2006).

insurance to encourage profitable asset accumulation. More importantly, formal insurance arrangements can protect households from catastrophic downside income risk when their self-protection through assets, out-migration or other means tends to be ineffective.

Second, that said, the governments might face difficulties in providing safety nets for the poor, especially in difficult times and in poor areas where budgets are already tight. A viable way out seems to be in labor markets. According to our estimates, the government should be able to facilitate rural-to-urban labor mobility and develop local enterprises in order to increase out-migration and the possibilities of local off-farm employment. These two factors could also make the poor more capable of self-protecting and self-financing and, at the same time, improve allocative efficiencies by attenuating their precautionary incentives.

Acknowledgments

The author is grateful to the insightful comments and discussion on an earlier draft from Albert Park, Katsushi Imai, Adam Ozanne, Bernard Walters, Xiaobing Wang, Nick Weaver, Chris Orme, and the participants in seminars at the University of Manchester, in the Chinese Economic Association (UK/Europe) Annual Conference 2010 at the University of Oxford and in the Royal Economic Society Annual Conference 2011 at Royal Holloway, University of London. The author also acknowledges very detailed and helpful comments and suggestions from two anonymous referees and the editors, B.M. Fleisher and Xiaobo Zhang, which have improved the paper substantially. This research is supported by the Ministry of Education of China Humanities and Social Science Research Funds (Grant No.: 13YJCZH231), and the Scientific Research Foundation for the Returned Overseas Chinese Scholars also from the Ministry of Education of China. The financial support from Brooks World Poverty Institute and the North American Foundation for the University of Manchester at the early stage of this research is also gratefully acknowledged.

References

Adato, M., Carter, M. R., & May, J. (2006). Exploring poverty traps and social exclusion in South Africa using qualitative and quantitative data. *Journal of Development Studies*, *42*(2), 226–247.
Antman, F., & McKenzie, D. (2007). Poverty traps and nonlinear income dynamics with measurement error and individual heterogeneity. *Journal of Development Studies*, *43*(6), 1057–1083.
Barnett, B. J., Barrett, C. B., & Skees, J. R. (2008). Poverty traps and index-based risk transfer products. *World Development*, *36*(10), 1766–1785.
Barrett, C. B., Marenya, P. P., Mcpeak, J., Marten, B., Murithi, F., Oluoch-Kosura, W., et al. (2006). Welfare dynamics in Rural Kenya and Madagascar. *Journal of Development Studies*, *42*(2), 248–277.
Baulch, B. (2011). *Why poverty persists: Poverty dynamics in Asia and Africa.* Cheltenham: Edward Elgar Publishing.
Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data methods. *Journal of Econometrics*, *87*(1), 115–143.
Bowlus, A. J., & Sicular, T. (2003). Moving towards markets? Labor allocation in rural China. *Journal of Development Economics*, *71*(2), 561–583.
Cai, F. (2010). Chinese rural reform in 30 years: An analysis in terms of institutional economics. *Frontiers of Economics in China*, *5*, 150–168.
Cao, S., Wang, X., & Wang, G. (2009). Lessons learned from China's fall into the poverty trap. *Journal of Policy Modeling*, *31*(2), 298–307.
Carter, M. R., & Barrett, C. B. (2006). The economics of poverty traps and persistent poverty: An asset-based approach. *Journal of Development Studies*, *42*(2), 178–199.
Carter, M. R., Little, P. D., Mogues, T., & Negatu, W. (2007). Poverty traps and natural disasters in Ethiopia and Honduras. *World Development*, *35*(5), 835–865.
Carter, M. R., & Lybbert (2012). Consumption versus asset smoothing: Testing the implications of poverty trap theory in Burkina Faso. *Journal of Development Economics*, *99*(2), 255–264.
Chamberlain, G. (1980). Analysis of covariance with qualitative data. *Review of Economics and Statistics*, *47*(1), 225–238.
Clarke, D., & Dercon, S. (2009). Insurance, credit and safety nets for the poor in a world of risk. *DESA working paper no. 81*. New York, USA: United Nations Department of Economic & Social Affairs.
de Brauw, A., & Rozelle, S. (2008). Migration and household investment in rural China. *China Economic Review*, *19*(2), 320–335.
de Janvry, A., & Sadoulet, E. (2006). Progress in modelling of rural households' behaviour under market failures. In A. de Janvry, & R. Kanbur (Eds.), *Poverty, inequality and development*. New York: Springer.
de Janvry, A., Sadoulet, E., & Zhu, N. (2005). The role of non-farm incomes in reducing rural poverty and inequality in China. *CUDARE working paper no. 1001*. : Department of Agricultural and Resource Economics, University of California, Berkeley.
Dercon, S. (1998). Wealth, risk and activity choice: Cattle in Western Tanzania. *Journal of Development Economics*, *55*, 1–42.
Dercon, S. (2004). Growth and shocks: Evidence from rural Ethiopia. *Journal of Development Economics*, *74*(2), 309–329.
Dercon, S. (2006). Risk, growth and poverty: What do we know, what do we need to know? *QEH working paper series no. 148*. : Oxford University.
Dercon, S. (2009). Fate and fear: Risk and its consequences in Africa. *Journal of African Economies*, *17*(2), 97–127.
Dercon, S., & Christiaensen, L. (2011). Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia. *Journal of Development Economics*, *96*(2), 159–173.
Dercon, S., Hoddinott, J., & Woldehanna, T. (2005). Shocks and consumption in 15 Ethiopian villages, 1999–2004. *Journal of African Economies*, *14*(4), 559–585.
Dong, F., & Featherstone, A. M. (2006). Technical and scale efficiencies for Chinese rural credit cooperatives: A bootstrapping approach in data envelopment analysis. *Journal of Chinese Economic and Business Studies*, *4*(1), 57–75.
Elbers, C., Gunning, J. W., & Kinsey, B. (2007). Growth and risk: methodology and micro evidence. *World Bank Economic Review*, *21*(1), 1–20.
Fafchamps, M. (2003). *Rural poverty, risk, and development.* Massachusetts: Elgar Publishing.
Fafchamps, M. (2009). Vulnerability, risk management, and agricultural development. *CEGA working paper series no. AfD-0904*. Berkeley: Center of Evaluation for Global Action. University of California.
Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data—or tears: An application to educational enrolments in states of India. *Demography*, *38*(1), 115–132.
Foster, A. D., & Rosenzweig, M. R. (2010). Microeconomics of technology adoption. *Annual Review of Economics*, *2*(1), 395–424.
Giesbert, L., & Schindler, K. (2010). Assets, shocks, and poverty traps in rural Mozambique. *DIW working paper no. 1073*. : DIW Berlin.
Giles, J. (2006). Is life more risky in the open? Household risk-coping and the opening of China's labor markets. *Journal of Development Economics*, *81*(1), 25–60.
Giles, J., & Yoo, K. (2007). Precautionary behavior, migrant networks and household consumption decisions: An empirical analysis using household panel data from rural China. *Review of Economics and Statistics*, *89*(3), 534–551.
Glauben, T., Herzfeld, T., Rozelle, S., & Wang, X. (2012). Persistent poverty in rural China: Where, why, and how to escape? *World Development*, *40*(4), 784–795.
Greene, W. (2003). *Econometric analysis.* New Jersey: Princeton Hall.
Hebel, J. (2003). Social welfare in rural China. *Journal of Peasant Studies*, *30*(3–4), 224–251.

Hoddinott, J. (2006). Shocks and their consequences across and within households in rural Zimbabwe. *Journal of Development Studies*, *42*(2), 301–321.
Honoré, B. E. (1992). Trimmed LAD and least squares estimation of truncated and censored regression models with fixed effects. *Econometrica*, *60*(3), 533–565.
Hoogeveen, J. G. M. (2001). Income risk, consumption security and the poor. *Oxford Development Studies*, *30*(1), 105–121.
Huang, J., Lin, J. Y., & Rozelle, S. (2003). What will make Chinese agriculture more productive? In N. C. Hope, D. T. Yang, & M. Y. Li (Eds.), *How Far across the river? Chinese policy reform at the millennium*. Stanford: Stanford University Press.
Imai, K., & You, J. (2013). Poverty dynamics of households in rural China. *Oxford Bulletin of Economics and Statistics,* http://dx.doi.org/10.1111/obes.12044, forthcoming.
Jacoby, H. G., Li, G., & Rozelle, S. (2002). Hazards of expropriation: Tenure insecurity and investment in rural China. *American Economic Review*, *92*(5), 1420–1447.
Jalan, J., & Ravallion, M. (1999). Are the poor less well insured? Evidence on vulnerability to income risk in rural China. *Journal of Development Economics*, *58*(1), 61–81.
Jalan, J., & Ravallion, M. (2001). Behaviour responses to risk in rural China. *Journal of Development Economics*, *66*(1), 23–49.
Jalan, J., & Ravallion, M. (2002). Geographic poverty traps? A micro model of consumption growth in rural China. *Journal of Applied Econometrics*, *17*(4), 329–346.
Jalan, J., & Ravallion, M. (2005). Household income dynamics in rural China. In S. Dercon (Ed.), *Insurance against poverty*. Oxford: Oxford University Press.
Jin, L., Chen, K. Z., Yu, B., & Huang, Z. (2011). How prudent are rural households in developing transition economies. *IFPRI discussion paper, no. 01127*.
Knight, J., Li, S., & Deng, Q. (2009). Education and the poverty trap in rural China: Setting the trap. *Oxford Development Studies*, *37*(4), 311–332.
Knight, J., Li, S., & Deng, Q. (2010). Education and the poverty trap in rural China: Closing the trap. *Oxford Development Studies*, *38*(1), 1–24.
Kolenikov, S., & Angeles, G. (2009). Social economic status measurement with eiscrete proxy variables: Is principal component analysis a reliable answer? *Review of Income and Wealth*, *55*(1), 128–165.
Lee, J., & Swada, Y. (2010). Precautionary savings under liquidity constraints: Evidence from rural Pakistan. *Journal of Development Economics*, *91*(1), 77–86.
Lipton, M. (1968). The theory of the optimising peasant. *Journal of Development Studies*, *4*(3), 327–351.
Liverpool, L. S. O., & Winter-Nelson, A. (2010). Poverty status and the impact of formal credit on technology use and wellbeing among Ethiopian smallholders. *World Development*, *38*(4), 541–554.
Lokshin, M. (2006). Difference-based semiparametric estimation of partial linear regression models. *The Stata Journal*, *6*, 377–383.
Lybbert, T. J., & Barrett, C. B. (2011). Risk-taking behavior in the presence of nonconvex asset dynamics. *Economic Inquiry*, *48*(4), 982–988.
Lybbert, T. J., Barrett, C. B., Desta, S., & Coppock, D. L. (2004). Stochastic wealth dynamics and risk management among a poor population. *The Economic Journal*, *114*(498), 750–777.
McDonald, J. F., & Moffitt, R. A. (1980). The use of tobit analysis. *Review of Economics and Statistics*, *62*(2), 318–321.
McKay, A., & Perge, E. (2013). How strong is the evidence for the existence of poverty traps? A multicountry assessment. *Journal of Development Studies*, *49*(7), 877–897.
McKenzie, D. J., & Woodruff, C. (2006). Do entry costs provide an empirical basis for poverty traps? Evidence from Mexican microenterprises. *Economic Development and Cultural Change*, *55*(1), 3–42.
Minten, B., & Barrett, C. B. (2008). Agricultural technology, productivity, and poverty in Madagascar. *World Development*, *36*(5), 797–822.
Montalvo, J. G., & Ravallion, M. (2010). The pattern of growth and poverty reduction in China. *Journal of Comparative Economics*, *38*(1), 2–16.
Morduch, J. (1995). Income smoothing and consumption smoothing. *The Journal of Economic Perspectives*, *9*(3), 103–114.
Moser, C., & Felton, A. (2009). The construction of an asset index measuring asset accumulation in Ecuador. In T. Addison, D. Hulme, & R. Kanbur (Eds.), *Poverty dynamics: interdisciplinary perspectives*. Oxford: Oxford University Press.
Naschold, F. (2012). "The poor stay poor": Household asset poverty traps in rural semi-arid India. *World Development*, *40*(10), 2033–2043.
Park, A. (2006). Risk and household grain management in developing countries. *The Economic Journal*, *116*(514), 1088–1115.
Park, A., & Ren, C. (2001). Microfinance with Chinese characteristics. *World Development*, *29*(1), 39–62.
Quisumbing, A., & Baulch, B. (2013). Assets and poverty traps in rural Bangladesh. *Journal of Development Studies*, *49*(7), 898–916.
Ravallion, M., & Chen, S. (2007). China's (uneven) progress against poverty. *Journal of Development Economics*, *82*(1), 1–42.
Rosenzweig, M. R., & Binswanger, H. P. (1993). Wealth, weather risk and the composition and profitability of agricultural investments. *The Economic Journal*, *103*(416), 56–78.
Rosenzweig, M. R., & Wolpin, K. I. (1993). Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investment in bullocks in India. *Journal of Political Economy*, *101*(2), 223–244.
Rui, L., & Xi, Z. (2010). Econometric analysis of credit constraints of Chinese rural households and welfare loss. *Applied Economics*, *42*(13), 1615–1625.
Sahn, D. E., & Stifel, D. (2003). Exploring alternative measures of welfare the absence of expenditure data. *Review of Income and Wealth*, *49*(4), 463–489.
Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data.* : MIT Press.
Yang, W. (2009). Economic structural changes and rural income: Evidence from Chinese provinces during the reform period. *China Economic Review*, *20*(4), 742–753.
Zimmerman, F. J., & Carter, M. R. (2003). Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints. *Journal of Development Economics*, *71*(2), 233–260.