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ABSTRACT

We consider risk sharing in rural China during its rapid economic transformation from the late 1980s through the late 2000s. We document an erosion of consumption insurance against both household-level idiosyncratic and village-level aggregate income shocks, and show that this decline is related to observable economic changes: the shift out of agriculture, the decline of publicly owned Township-and-Village Enterprises, and increased migrant work. Further evidence suggests that as these changes took place at the village level, higher levels of government failed to offset these effects through the tax-and-transfer system, leaving households more exposed to both idiosyncratic and village-aggregate risk.

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1 Introduction

To mitigate the negative effects of unexpected income fluctuations, households rely on their own savings as well as formal insurance contracts and informal insurance arrangements. In many developed countries, private (formal and informal) insurance contracts and public insurance systems (e.g., unemployment insurance programs) play a prominent role in insuring income risk. In less developed countries, with little access to formal insurance, informal risk sharing plays a larger role, typically within smaller groups such as villages (e.g., Kinnan and Townsend, 2012; Munshi and Rosenzweig, 2016; Morten, 2019; Meghir, Mobarak, Mommaerts *et al.*, 2021). Many of these countries at some point experience a period of development and transformation of public and private institutions. While there is a large literature on the role of informal networks more generally during a country's process of development (Kranton, 1996; Banerjee and Newman, 1998; Munshi, 2014; Heß, Jaimovich, and Schündeln, 2021), there is much less empirical work focusing on how informal insurance arrangements change during such periods. In this paper, we study such arrangements over the course of one of the largest and fastest growth transformations in modern history: rural China.

To do this, we propose a framework to estimate the extent of risk sharing both within small risk-sharing groups (such as villages) and across these groups within a broader economy. We then use this framework to trace the evolution of consumption insurance over time as institutional changes along a country's development process impact risk-sharing arrangements. Our framework builds on the seminal complete market tests of Townsend (1994) as well as on the partial insurance model of Blundell, Pistaferri, and Preston (2008) and an extended version of that by Attanasio, Meghir, and Mommaerts (2015). Empirically, our analysis expands on Santaeulàlia-Llopis and Zheng (2018), who document that consumption insurance declined substantially in China from the late 1980s through the late 2000s, by showing in additional detail how consumption insurance both within and across rural villages has declined and exploring the structural reasons underlying this decline.

The case of rural China is particularly interesting because of the speed of change and the profound impact it could have on consumption insurance. Since the late 1970s, rural China embarked on a transformation from a planned economy centered around agriculture to an industrial economy, first largely through public ownership in the 1980s and 1990s and then swiftly transitioning to pri-

vate ownership in the 2000s. Along with the shift in productive organization, a tax recentralization reform in 1994 left lower-level governments with greater responsibility in funding local public goods and social protections. These economic and fiscal transformations may have had major ramifications on the ability of individual households and small communities to insure idiosyncratic shocks: under the planned economy, economic resources were allocated from the center out and migration rates were low, allowing for credible commitment to risk sharing networks within the village, while the central government provided insurance against aggregate village risks (Perkins, 2014). Under the transformed market economy, the previously centralized resources became gradually privatized, household migration rates increased, and localities had to be more self-sufficient, suggesting a weakening of communal risk sharing and a weakening of insurance from the central government against aggregate risk (Zhu, 2012).

We conduct two sets of exercises to study the change in risk sharing over this time period. Our data for these tests come from the 1989 through 2009 waves of the China Health and Nutrition Survey (CHNS), which contains rich information on household income, consumption, demographics, and economic activities, as well as village level characteristics for 150 rural villages across China.[1] First, we run regression tests of complete insurance à la Townsend (1994). We test both the hypothesis that idiosyncratic income shocks are diversified *within villages* as well as the hypothesis that village level shocks are insured *across villages*. We reject full insurance against both types of risk. Moreover, our point estimates suggest that consumption insurance worsens over the course of our sample period.

While this first exercise suggests the presence of incomplete insurance, it does not distinguish between different types of income shocks, such as permanent or transitory shocks. This distinction can be important given that different types of shocks have profoundly different effects on household welfare. For example, transitory shocks are more easily self-insured through savings, while more permanent shocks might need other forms of formal or informal insurance to be smoothed out. In our second set of exercises, we build on the partial insurance framework developed by Blundell, Pistaferri, and Preston (2008) to decompose income shocks into transitory and permanent components and measure how these different shocks are reflected into consumption, as well

[1] Our data work builds on that in Santaeulàlia-Llopis and Zheng (2018), who carefully cross-validated the CHNS with aggregate statistics reported in the Statistical Yearbooks and other household-level datasets such as China Household Income Project and Urban and Rural Household Surveys.

as the expansion of this approach developed by Attanasio, Meghir, and Mommaerts (2015) that decomposes permanent and transitory income shocks into components that are common within a village—and therefore cannot be easily insured by the village—and components that are purely idiosyncratic and can therefore be insured within the village. This approach complements the regressions in our first set of exercises in that it allows us to quantify the magnitude of consumption insurance against different types of shocks—permanent and transitory, and village-level and purely idiosyncratic—and how this insurance has changed over time.

We estimate this partial insurance model using a method of moments estimator and find that there is large scope for within-village risk sharing: close to 60% of permanent income shocks and 90% of transitory income shocks are idiosyncratic and thus insurable within a village. Interestingly, this characterization of household income risk is relatively constant during the process of industrialization: although the variance of both permanent and transitory components increases slightly after the end of the 1990s, the percentage that is insurable at the village level does not change much. When looking at the dynamics of consumption changes, we find that all types of income shocks were well insured in the early years of our sample period. However, this insurance deteriorated substantially by the end of our sample period, particularly for aggregate shocks. Specifically, compared to the near-perfect insurance achieved in the 1990s, only 40% of village-aggregate permanent shocks were insured in the 2000s. Consumption equivalent calculations imply that the welfare cost of these changes to risk and insurance is on the order of 0.5 to 1.5% of consumption. Moreover, this welfare cost is almost entirely driven by the erosion of insurance as opposed to an increase in income risk, and most of this insurance effect is due to changes in insurance against village-aggregate permanent shocks.

Our estimates of the degree of consumption insurance obtained by these two different approaches imply that households in rural China experienced declining insurance against income risk over the course of China's economic transformation, particularly against aggregate risk to villages. In the final part of the paper, we explore possible mechanisms behind the decrease in consumption insurance both within the village and from outside sources. We first show that the deterioration of insurance was more pronounced in regions of the country where (a) fewer households worked in the agriculture sector, (b) migration rates were higher, and (c) there was a lesser presence of publicly owned Township-and-Village Enterprises (TVEs). Reduced agricultural activity, increased

migration and urbanization, and the declining presence of TVEs were all important features of the economic transformation of rural China in the 1990s and 2000s, and they all may weaken the ability of the village to provide insurance.[2] In addition to these economic mechanisms that could directly weaken inter-household ties, other factors such as familiarity, trust, and social sanctions may also weaken as a result of economic changes and may lead to the deterioration of insurance (see, for instance, Attanasio, Barr, Cardenas *et al.*, 2012; Barr and Genicot, 2008).

To explore the decline of across-village insurance, we investigate the changing role of the central government by directly measuring inter-governmental transfers using data from county fiscal balance sheets from 1993 to 2007. We find that county government tax revenue and spending increasingly co-varied with output over the time period of study, while transfer programs, which were ostensibly set up for insurance and redistribution purposes, became less negatively correlated with income. While only suggestive, these patterns are consistent with the notion that the inter-governmental transfer system instituted by the 1994 tax reform became less progressive over the course of economic transition, which corroborates the deterioration of across-village insurance documented in our partial insurance estimates.

This paper builds on a literature that documents the loss of insurance associated with China's collective past. Several studies infer this decline in insurance from the rising saving rate among urban households (Chamon and Prasad, 2010; Meng, 2003; He, Huang, Liu *et al.*, 2018), while Santaeulàlia-Llopis and Zheng (2018) infers the decline from the changing relationship between income and consumption. We take the latter approach, and our main contribution is an emphasis on the contrast between within- and across-village insurance and on the distinction between transitory and permanent shocks. We show the declining insurance against permanent income risk is primarily due to a break-down of insurance against village-aggregate risk, suggesting a shortfall of public insurance programs to complement policies which were enacted to promote growth but also weakened within-village insurance. Our results also complement studies of China's fiscal decentralization process, which generally finds negative effects on regional disparities in income and welfare indicators such as health and education, especially over the time period we consider (Dollar and

[2]Other studies also find evidence that these features weaken within-village insurance: Mazur (2023) finds that stronger agricultural institutions complement informal risk-sharing; Morten (2019) and Meghir, Mobarak, Mommaerts *et al.* (2021) find that migration can either weaken or strengthen informal risk-sharing arrangements depending on the riskiness of migration; and Ábrahám and Laczó (2018) show theoretically that a public storage technology (like a TVE) can strengthen informal risk-sharing.

Hofman, 2006; Fan, Kanbur, and Zhang, 2011; Song, 2013; Piketty, Yang, and Zucman, 2019; Hao, Liu, Lu *et al.*, 2021; Jiang, Zheng, and Zhu, 2023). In addition to the distributional consequences of fiscal decentralization, we emphasize its negative consequence on risk sharing across villages in rural China.

More generally, our findings suggest that the growth experience of China offers valuable lessons to other transition economies. How much risk-sharing is sustained within a group (and *across* groups) depends on economic institutions, on the economic environment and, possibly, frictions that prevent market completeness, such as limited commitment, hidden resources, or hidden effort (Ligon, Thomas, and Worrall, 2002; Attanasio and Pavoni, 2011). As countries transition from agrarian or collective economies to formal market-based economies with new opportunities, new resources, and new institutions, the level of risk sharing that can be sustained may evolve as a result. While the nature of our data prevents us from identifying the specific imperfections that prevent full risk sharing in the new environment, we stress the reduction in the importance of local TVEs and agriculture in the economy as well as the increase in migration to explain this shift. In this sense, our paper and findings relate to a literature that studies the effect of changes in the economic or policy environment on informal insurance, including migration incentives (Meghir, Mobarak, Mommaerts *et al.*, 2021), aid programs (Angelucci and De Giorgi, 2009), savings accounts (Dupas, Keats, and Robinson, 2019), credit markets (Banerjee, Breza, Chandrasekhar *et al.*, 2021), microfinance (Feigenberg, Field, and Pande, 2013), and formal insurance (Munshi and Rosenzweig, 2016).[3] As large panel datasets from developing countries become increasingly available, our framework has potentially wide application for further study of these issues.[4]

The rest of the paper is organized as follows. Section 2 provides a brief description of the changing economic landscape of rural China, including agricultural reforms, the rise and fall of collectively owned TVEs, and the decentralization and recentralization of fiscal power. In Section 3, we describe our partial insurance framework, and Sections 4 and 5 present our data and main findings on income risk and the change in consumption insurance over our sample period, respectively.

[3] Kinnan, Wang, and Wang (2018) and Dai, Mookherjee, Munshi *et al.* (2019) look at the role of networks in China during the process of economic growth, but do not look explicitly at insurance. Attanasio and Krutikova (2020) analyze the role of the quality of information on the extent of consumption insurance within informal networks in Tanzanian extended families.

[4] For example, the Indonesia Family Life Survey (IFLS), the Russia Longitudinal Monitoring Survey (RLMS), the EGC-ISSER Ghana Panel Survey, the EGC-CMF Tamil Nadu Panel Survey, and the LSMS-ISA offer opportunities to apply our framework to other settings.

Section 6 presents evidence that the loss of insurance is associated with the decline in agricultural and collective activities as well as a diminishing insurance role played by the inter-governmental fiscal system. Section 7 concludes.

2 The Changing Risk-Sharing Institutions of Rural China

The economic landscape of rural villages in China has undergone dramatic changes over the past several decades. In this section, we provide an overview of the risk-sharing institutions and broader economic transformation that occurred in rural China over the past 70 years.

Prior to the founding of the People's Republic of China in 1949, rural life was embedded in a traditional peasant society and was loosely organized into "standard market areas" that consisted of a market town and a collection of villages around it within a day's walk (Skinner, 1964). Most villagers worked on their farmland and periodically travelled to the market town to buy and sell produce and livestock or to purchase other goods.

Beginning in the early 1950s, the newly formed government introduced agricultural collectives that took over agricultural production from individual households and organized production into collectives corresponding to each market area. Ownership of land was transferred to the collectives, and individuals worked the land in exchange for "work points".[5] Following a collective's harvest each year, the net income earned by the collective was then distributed to households based on their accumulated work points after setting aside funds for investment and public welfare.[6] Free education and basic medical care was thus funded and provided through the collectives. As such, this collective system reduced exposure to idiosyncratic agricultural shocks and mitigated idiosyncratic health risks; moreover, it also reduced exposure to village-aggregate risk as a collective included multiple villages and when necessary higher-level government stepped in to insure collectives against larger aggregate shocks (Naughton, 2007).

A primary drawback to this system was that work points were accumulated based on time inputs, which created incentives to shirk.[7] In the late 1970s, the Household Responsibility System

[5]The new government also instituted China's *Hukou* system that placed major restrictions on the ability to find work and receive public services in localities other than one's birthplace, thus curtailing migration flows from rural areas to cities.

[6]The work-point system made it easy to integrate non-agricultural professionals such as doctors and teachers into the system, namely by awarding points to them in the same way as to farmers.

[7]As Naughton (2007) writes: "The collectives were not an efficient system for organizing agricultural production.

was introduced to solve these incentive problems. Under this system, land was still publicly owned but households were allowed to be the residual claimant of their agricultural output above a quota. This sparked an improvement in agricultural productivity (Lin, 1992).

At the same time, reforms in the rural industrial sector led to a shift out of agriculture into industry. These reforms primarily consisted of the introduction of a new type of enterprise, the Township-and-Village Enterprise (TVE), which were collectively owned and managed by the village or township government.[8] Importantly, because of their independence from the central government, TVE revenue came to finance many of the village's public goods (e.g., medical care, education, and infrastructure investment) that had previously been financed by agricultural collectives. This organizational shift led to a dramatic decrease in the central government's share of tax revenues, from a peak of 40% in 1984 to less than 25% in 1993, and paved the way for a major tax reform (Bird and Wong, 2005; Donaldson, 2017).

The first three panels of Figure 1 reflect these changes using data from the China Rural Statistical Yearbooks and the TVE Statistical Yearbooks over the 1978-2010 period. Panel (a) shows that rural per capita income and consumption expenditure grew at an average rate of over 6% annually. Panel (b) shows that the share of the rural population working in agriculture experienced a sustained decline after 1978, and Panel (c) shows that collective TVEs flourished for over a decade since the late 1970s (Naughton, 1994).

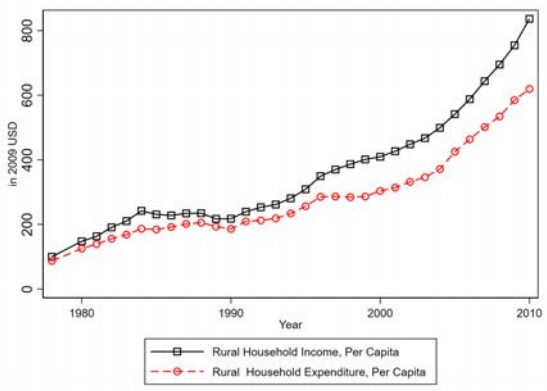
Over time, private households in rural areas gradually formed alliances with their village or township governments to register their private enterprises under the auspices of TVEs. Different from collective TVEs, these "TVEs" were private enterprises all but in name (Huang, 2012). As Figure 1(c) shows, until 1984 all TVEs were collectively owned, and their output accounted for up to 10% of domestic GDP. After 1984, privately run TVEs slowly took off and by 1996 accounted for about 40% of the TVE sector's output. By 2010, there were virtually no collective TVEs remaining, while privately run TVEs made up almost a quarter of domestic GDP.

At a broader level, the 1990s saw new leadership of the country, made up of a group of urban technocrats who pursued a new national strategy that prioritized the economic development of

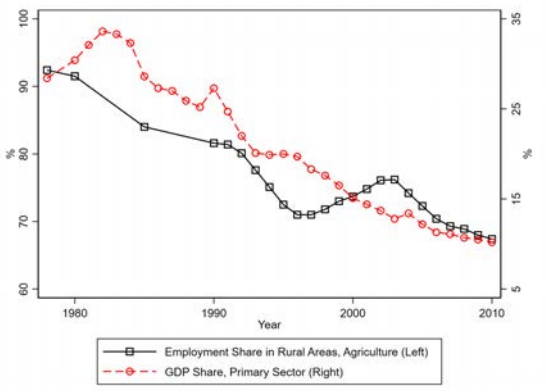
However, they were a surprisingly adequate system for organizing much of the rest of rural social and economic life" (p. 238).

[8] TVEs were distinct from state-owned enterprises (SOEs), which were still fully integrated into the central planning system at the time.

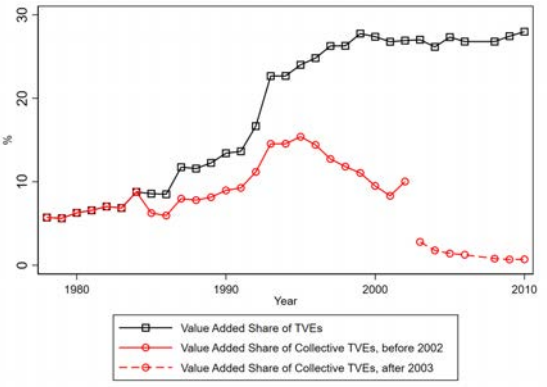
Figure 1: Economic Trends in Rural China, 1978-2010



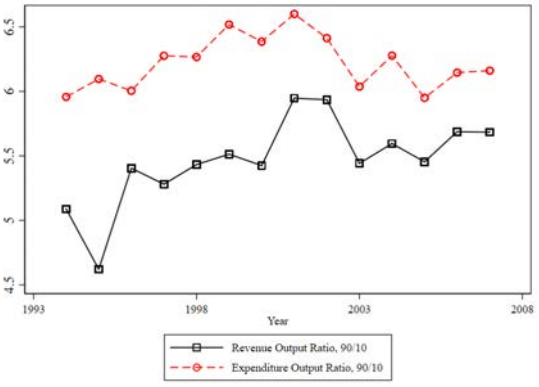
(a) Household income and consumption



(b) Agricultural sector



(c) Industrial sector



(d) County fiscal resources

Note: Data come from China Rural Statistical Yearbooks for Panels (a) and (b), China TVE Statistical Yearbooks for Panel (c), and EPS county-level fiscal balance sheets for Panel (d). In Panel (a), the numbers are annual per capita household income and consumption, valued in 2009 US dollars (based on rural consumer price indices). In Panel (b), the primary sector includes agriculture, forestry and mining. Panel (d) shows 90/10 percentile ratios of county-level fiscal revenue to output and 90/10 percentile ratios of county-level local fiscal expenditure to output.

coastal urban areas over the countryside. One of the most important fiscal reforms of the era was the 1994 tax reform, which recentralized fiscal power by requiring that 75% of all local value added taxes (the major tax levied by the industrial sector) go to the central government's coffer. This left local governments with few resources at their disposal. In the same year, private enterprises were legalized, which essentially led to the demise of collective TVEs (as seen in Panel (c) of Figure 1), as they either lost out to their private competitors or themselves became privatized.

As a result of these reforms, regional fiscal disparities between the rural hinterland and the urban coast widened (Shen, Jin, and Zou, 2012). Figure 1(d) shows this growing regional disparity by reporting the 90/10 ratio of fiscal revenue as a share of output by county (black) and the analogous ratio for fiscal expenditure (red) starting in 1993. The relatively poor local governments in the rural areas increasingly faced financial difficulty in performing its role as the provider of public service and social safety net. It was not until the mid-2000s that the central government realized the urgency to intervene and to design formal social insurance programs for rural China.[9]

The sample period of our study – 1989 to 2009 – captures the last prosperous years of the collective TVEs before its protracted decline together with the ensuing period of local governmental paralysis in rural China.

3 Quantifying Deviations from Perfect Risk Sharing

To understand the implications of the institutional changes outlined in Section 2 on risk sharing, we next describe a conceptual framework of risk sharing within and across groups and derive empirical tests that we then take to data.

3.1 A model of risk sharing within and across villages

Consider a group with many individual households, such as a village. The economy we consider is made of many of such groups. Household income evolves as a permanent-transitory process. As is commonly assumed in this literature (e.g., Meghir and Pistaferri, 2004), the stochastic structure of log income for household i in village v at time t is made up of three components: (1) a deterministic

[9]For example, the central government rolled out the New Rural Cooperative Medical Insurance Scheme pilot program in 2003 and gradually achieved full coverage in 2010, though its effectiveness has been limited (Wagstaff, Lindelow, Wang *et al.*, 2009). The New Rural Social Security and Pension Scheme pilot program was initiated in 2009.

component which we model as a function of demographics and other deterministic variables $z_{i,v,t}$, (2) a permanent component $P_{i,v,t}$, and (3) a transitory component $e_{i,v,t}$ that is assumed to be serially uncorrelated.[10] In addition, measured income is affected by a multiplicative measurement error $r^y_{i,v,t}$ that is independent and identically distributed. Thus we have

$$\log Y_{i,v,t} = z_{i,v,t}\varphi_t + P_{i,v,t} + e_{i,v,t} + r^y_{i,v,t} \tag{1}$$

where

$$P_{i,v,t} = P_{i,v,t-1} + u_{i,v,t} \tag{2}$$

where $u_{i,v,t}$ are serially uncorrelated shocks to permanent income. The annual growth in unexplained log income $y_{i,v,t}$ is then given by:

$$\Delta y_{i,v,t} = u_{i,v,t} + \Delta e_{i,v,t} + \Delta r^y_{i,v,t} \tag{3}$$

To study the implications of perfect risk sharing and complete markets, following Townsend (1994) and others, we consider the problem of a social planner that maximizes the weighted average of household utilities within a risk sharing group v, with household Pareto weights $\pi_{i,v}$. Membership of group v defines the risk sharing arrangements available to the group, which could include technologies to transfer resources over time (e.g., saving or loans) and across households. It is also possible that there is some risk sharing across groups. We first discuss the properties of risk sharing *within* group v, and then characterize risk sharing *across* groups.

We assume that household instantaneous utility depends on consumption $C_{i,v,t}$ and thus the first order conditions for the planner problem are:

$$\beta_{i,v,t}\pi_{i,v}\frac{\partial U(C_{i,v,t})}{\partial C_{i,v,t}} = \mu_{v,t} \tag{4}$$

where $\beta_{i,v,t}$ is the discount factor relevant for household i in group v at time t, possibly reflecting de-

[10] A more flexible specification would allow for an MA(1) process with persistence θ, but because we do not have consecutive years of data, we cannot rely on both first-order and second-order autocovariances (because the first-order autocovariance is not observed with non-consecutive data) and thus we would not be able to identify the persistence parameter. Moreover, a standard test of persistence by estimating higher-order autocovariances would not work because even without persistence (i.e., $\theta = 0$), the "first"-order autocovariance is non-zero (see equation (18) in Appendix B) and even with persistence the "second"-order autocovariance is zero.

mographics and other time varying variables that might affect marginal utility. $\mu_{v,t}$ is the multiplier associated with the resource constraint in a given state of the world for group v at time t (weighted by the inverse probability of that state), and includes resources obtained from outside the group (e.g., from risk sharing *across* groups) as well as resources shifted over time through borrowing and saving. We note that equation (4) holds in any possible state of the world for group v at time t. If we assume that $\beta_{i,v,t} = e^{-\theta z_{i,v,t} - \varepsilon_{i,v,t}}$, where $z_{i,v,t}$ and $\varepsilon_{i,v,t}$ are observable and unobservable taste shifters respectively, and that the utility function is of the CRRA type with coefficient σ, taking the log of equation (4) gives:

$$\sigma \log C_{i,v,t} = \log \mu_{v,t} - \log \pi_{i,v} + \theta z_{i,v,t} + \varepsilon_{i,v,t} \tag{5}$$

Equation (5) is the basis for a standard test of perfect insurance (Townsend, 1994). The second term on the right hand side of the equation does not depend on time and is therefore a household fixed effect, while the first term does not depend on i and is therefore a time-by-group effect. We now add income to the right hand side and divide by σ to obtain:

$$c_{i,v,t} = \nu_{v,t} + \tilde{\pi}_{i,v} + \psi y_{i,v,t} + \epsilon_{i,v,t} \tag{6}$$

where $c_{i,v,t} \equiv \log C_{i,v,t} - \tilde{\theta} z_{i,v,t}$ is residualized log consumption and $\epsilon_{i,v,t}$ reflects measurement error and any unobserved taste shocks that affect the marginal utility of consumption. Within this specification, the perfect risk sharing hypothesis is that $\psi = 0$ and hence that income does not enter equation (6): after controlling for the household fixed effect (which captures the time invariant Pareto weight) and the time-by-village fixed effect that captures the time t resource constraint relevant for the risk sharing group (which might take into account any risk sharing across groups or other self insurance mechanisms such as saving), household income is irrelevant for the determination of household consumption.

An alternative specification to equation (6) is to take the first difference over time:

$$\Delta c_{i,v,t} = \Delta \nu_{v,t} + \psi \Delta y_{i,v,t} + \Delta \epsilon_{i,v,t} \tag{7}$$

where the unobserved Pareto weight $\tilde{\pi}_{i,v}$ is differenced out. Once again the test of perfect insurance

is $\psi = 0$.

Equations (6) and (7) have different power against different alternatives to the perfect risk sharing model. If income follows the process in equation (1), the income term in equation (6) can be expressed as the sum of one transitory shock and an infinite series of permanent shocks. In equation (7), instead, the income term is given by one permanent shock and the difference between two transitory shocks. The failure to insure permanent shocks will thus be more apparent when estimating equation (6) because the *level* of income can be interpreted as the cumulation of permanent shocks with an additional transitory shock, while *changes* in income contain only one permanent shock and two transitory ones. Permanent shocks, therefore, count of a relatively larger fraction of the variance of income in equation (6) than in equation (7).[11]

The tests in equations (6) and (7) define a risk sharing group as a village and thus test for perfect insurance against idiosyncratic income shocks *within* villages, given any risk sharing that might be happening across villages (controlled for by the multipliers $\nu_{v,t}$). These tests, however, are silent about insurance against shocks that are aggregate to the village, such as regional agricultural shocks.

Considering the social planner problem for the entire economy (made up of many villages), we can additionally test for perfect risk sharing *across* villages, given the risk sharing within villages. To formalize this idea, it is convenient to define village-level averages of individual consumption and income in equation (6): $\bar{c}_{v,t} \equiv \frac{1}{N_v}\sum_{i=1}^{N_v} c_{i,v,t}$ and $\bar{y}_{v,t} \equiv \frac{1}{N_v}\sum_{i=1}^{N_v} y_{i,v,t}$, where N_v is the number of households in each village v. From the social planner problem of sharing risk across villages one can then get the analogue of equation (6):

$$\frac{1}{N_v}\sum_{i=1}^{N_v} c_{i,v,t} \equiv \bar{c}_{v,t} = \bar{\pi}_v + \nu_t + \bar{\psi}\bar{y}_{v,t} + \bar{\epsilon}_{v,t} \tag{8}$$

where $\bar{\psi} = 0$ under perfect risk sharing across villages.

Analogously, taking the first differences of this equation, one gets the village level equivalent of equation (7),:

$$\Delta\bar{c}_{v,t} = \Delta\nu_t + \bar{\psi}\Delta\bar{y}_{v,t} + \Delta\bar{\epsilon}_{v,t} \tag{9}$$

[11] Attanasio and Davis (1996) follow a similar logic and additionally consider higher order differences. The higher the difference ordering, the higher is the weight given to permanent shocks.

In these two equations, $\bar{\psi}$ measures deviations from perfect risk sharing *across* villages while, in equations (6) and (7), ψ measures deviations from perfect risk sharing *within* villages.

In Section 5, we estimate regressions based on equations (6) to (9) for different time periods to document how deviations from perfect risk sharing (within and across villages) have changed over time.

3.2 How Different Components of Income Are Reflected in Consumption

An alternative approach, which differentiates the ability to insure different types of shocks, is to model explicitly the various components of the income process and estimate which is reflected in consumption. To investigate more precisely the mechanisms underpinning the lack of complete risk sharing, therefore, we consider villages as risk sharing groups and, following Blundell, Pistaferri, and Preston (2008), we identify what fractions of permanent and transitory shocks within a village are reflected in consumption changes and therefore are not insured. Furthermore, we use the extension of Blundell, Pistaferri, and Preston (2008) proposed by Attanasio, Meghir, and Mommaerts (2015) to consider insurance both across and within villages.

Starting from the specification of income in equations (1) and (2), Blundell, Pistaferri, and Preston (2008) show that in a simple life-cycle model of consumption where individuals hold a single asset that can be used to insure income shocks through savings, the only relevant feature of individual income shocks is their durability, not their correlation across people. More specifically, unexplained innovations to consumption are approximated as:

$$\Delta c_{i,v,t} = \delta u_{i,v,t} + \gamma e_{i,v,t} + \Delta r^{c}_{i,v,t} + \xi_{i,v,t} \tag{10}$$

where δ measures the degree to which (own) permanent shocks pass through to consumption and γ measures the degree to which (own) transitory shocks pass through to consumption (and $r^{c}_{i,v,t}$ and $\xi_{i,v,t}$ represent classical measurement error and independent innovations, respectively). In such a simple model, interactions across individuals are not considered. As such, evidence that a non-negligible fraction of permanent shocks is *not* reflected into consumption is known as *excess smoothness of consumption* (Campbell and Deaton, 1989), which was interpreted by Attanasio and Pavoni (2011) as reflecting the ability to smooth idiosyncratic shocks with tools beyond a single

asset for saving.

Our approach to understanding this excess smoothness is to incorporate interactions across individuals, using the methodology developed by Attanasio, Meghir, and Mommaerts (2015) to distinguish between village-level and purely idiosyncratic shocks. Therefore, we allow for insurance over and above that implied by the simple life cycle model by including risk-sharing networks that can provide transfers, and also allow insurance to differ for shocks of different origin. To do this, we express the income process in equation (3) in terms of village-average components and the deviation of the household shocks from the village averages. In particular, we define $u^V_{v,t} = \frac{1}{N_v}\sum_{i=1}^{N_v} u_{i,v,t}$ as the aggregate permanent shock to village resources for village v of size N_v, and $u^I_{i,v,t} = u_{i,v,t} - u^V_{v,t}$ as the idiosyncratic permanent shock to household i in village v, such that $u^V_{v,t} + u^I_{i,v,t} = u_{i,v,t}$ and $\sum_{i=1}^{N_v} u^I_{i,v,t} = 0$. We decompose transitory shocks analogously: $e^V_{v,t} + e^I_{i,v,t} = e_{i,v,t}$. An important point to note about this decomposition is that the aggregate shocks ($u^V_{v,t}$ and $e^V_{v,t}$) consist of both shocks that are traditionally conceptualized as aggregate (i.e., each household in a village is hit by the same shock) as well as the average of idiosyncratic shocks which, in small villages, will not necessarily average to zero since the law of large numbers does not apply (see Appendix C for more details). Using this decomposition, we rewrite equation (3), the growth in log (unexplained) income, as:

$$\Delta y_{i,v,t} = u^V_{v,t} + u^I_{i,v,t} + \Delta e^V_{v,t} + \Delta e^I_{i,v,t} + \Delta r^y_{i,v,t} \tag{11}$$

The decomposition of income shocks into idiosyncratic and village-aggregate components allows us to quantify what percentage of shocks *could* be insured by the village, which effectively defines the risk sharing opportunities that are feasible for households in a village.[12] Idiosyncratic shocks are – by definition – household-level deviations from the village-average shock, and hence the village network can redistribute funds between households to smooth these shocks. Village-aggregate shocks, on the other hand, cannot be smoothed by village networks. Therefore, the pass-through of idiosyncratic income shocks to consumption may differ from the pass-through of village-aggregate shocks.

To incorporate this income decomposition into consumption, we rewrite equation (10), the

[12]There is no loss of generality and no particular restriction implied by the way we have written equation (11).

growth in log (unexplained) consumption, as:

$$\Delta c_{i,v,t} = \delta_I u^I_{i,v,t} + \delta_V u^V_{v,t} + \gamma_I e^I_{i,v,t} + \gamma_V e^V_{v,t} + \Delta r^c_{i,v,t} + \xi_{i,v,t} \tag{12}$$

where δ_V measures the degree to which village-aggregate permanent shocks pass through to consumption and δ_I measures the degree to which idiosyncratic permanent shocks pass through to consumption. Similarly, γ_V and γ_I measure the sensitivity of consumption to transitory shocks that are village-aggregate and idiosyncratic, respectively. Identification of this model is discussed in Appendix B.

Estimation of the models in equations (11) and (12) proceeds in three main steps. In the first step, we regress log income and log consumption on a set of demographics to isolate residual unexplained income and consumption.[13] Second, we estimate the variances of the income parameters of equation (11), allowing them to differ by sub-periods 1989-1997 and 1998-2009.[14] In the third step, we estimate four transmission parameters and two variances from the consumption equation, using the income variances estimates from the first step. For each step, we use diagonally-weighted minimum distance. Standard errors are calculated by block bootstrap over all three steps of the estimation procedure, clustering at the village level.

4 Data

To estimate the models described in Section 3, we primarily use data from the China Health and Nutrition Survey (CHNS), a longitudinal survey of households across China.[15] The survey is designed to include information for evaluating the health, nutrition, and family planning policies and programs implemented by national and local governments. To collect this information, it includes a Household Survey and a Community Survey; for the latter, someone who is knowledgeable about village affairs is asked basic facts about the village. The CHNS currently has 10 waves of which we use the first 8, spanning 1989 to 2009, conducted in 1989, 1991, 1993, 1997, 2000, 2004, 2006,

[13] The set of demographics include dummies of sex, age, education level, province of residence and ethnic minority separately by urban status and by year.

[14] Unfortunately, we cannot identify the variance of measurement error in income because it requires consecutive years of data. Instead, we run sensitivity checks to different assumptions for its value.

[15] The China Health and Nutrition Survey (CHNS) is a collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute for Nutrition and Health at the Chinese Center for Disease Control and Prevention.

and 2009, and covering nine geographically diverse provinces that are at various stages of economic development. Although the CHNS sample is not nationally representative, the provinces it covers represent about 43% of the country's total population and of its GDP. The CHNS is also the only publicly available panel data that spans a significant part of the economic transition.

We restrict our sample to rural households.[16] We also restrict the sample by trimming the top and bottom 1% of the income and consumption distributions and dropping households with missing demographic information. This results in 13,464 household-year observations from 149 unique villages. More details on sample selection are found in Appendix A.

Summary statistics of our analysis sample are found in Tables 1 and 2. Table 1 reports household-level statistics from the Household Survey. There are an average of 17 sampled households per village.[17] Due to the panel nature of the dataset, the average age of the households increased from 40 to 50 during the 20 year sample period. The majority of the households are headed by a male and are of Han ethnicity. The level of education of the head improved over the sample period, but even in 2009 about 80% of heads had less than nine years of education. Over the sample period, there was a marked shift in occupations from farming and collective enterprises, which together comprised almost 85% of workers in 1989 and only 50% in 2009, to private enterprise, which comprised 4% of workers in 1989 and almost 22% in 2009.

From the detailed data on household production activities and labor market experiences, we construct a measure of household total income, which includes agricultural income from farming, gardening, livestock raising, and fishing (calculated as the value of output minus costs), non-agricultural business income (revenue minus expenses), capital income from land leases and asset rentals, labor market income, and public and private transfers.[18,19] Our baseline measure of income

[16]The definition of a rural household is a household who resides either in a suburban neighborhood of a city or in a village of a rural county. Under the same definition, a town in a rural county would be classified together with a district in a city as urban. In terms of the local economic conditions, a suburb of a city looks more similar to a village than to a city neighborhood, while a town in a rural county looks more similar to a city neighborhood than to a village. In the rest of the paper, to avoid confusion, we refer to our communities as "villages," which in principle include both villages in rural counties and suburbs in cities.

[17]In Appendix F.3 we show that the main results of the paper remain virtually unchanged if we were to drop the bottom 5% of villages with fewer than 14 households sampled.

[18]This measure of income is pre-tax but includes public transfers. The CHNS does not ask about taxes paid, but in general average tax rates of rural households were very low during our sample period, at around 5% on average (authors' calculation based on the Rural Household Survey; see Appendix Figure 3). Public transfers (e.g., subsidies for meat or groceries, health, housing, and various fuel and safety net subsidies) were also a small fraction of income for our sample of rural households (in contrast, such subsidies for urban households were around 30%).

[19]The detailed description of variable construction is found in Appendix A of Santaeulàlia-Llopis and Zheng (2018).

Table 1: Summary Statistics, CHNS Household Survey, 1989-2009

	1989	2000	2009
Head's Age	39.64	44.78	49.91
	(9.79)	(9.36)	(8.50)
Household size	4.06	3.79	3.62
	(1.05)	(1.08)	(1.19)
Number of children in household	1.27	0.80	0.43
	(0.95)	(0.81)	(0.65)
Female head	0.10	0.09	0.08
	(0.30)	(0.28)	(0.27)
Minority head	0.17	0.15	0.16
	(0.37)	(0.36)	(0.36)
Education: none	12.49	6.67	3.53
	(33.07)	(24.95)	(18.46)
Education: 9th grade or more	14.64	15.44	19.84
	(35.36)	(36.15)	(39.90)
Occupation: farmer	54.01	60.28	39.69
	(49.85)	(48.95)	(48.94)
Occupation: state/collective enterprise	29.91	16.72	10.31
	(45.80)	(37.33)	(30.42)
Occupation: private enterprise	3.85	12.39	21.61
	(19.24)	(32.95)	(41.17)
Annual disposable income	1126	2149	4132
	(785)	(1698)	(3440)
Annual income excluding private transfers	1110	2089	4011
	(779)	(1674)	(3436)
Annual consumption	1051	1486	1852
	(495)	(966)	(1122)
Annual food consumption	969	1433	1662
	(472)	(980)	(1030)
Number of sampled households per village	16.72	17.57	16.76
	(2.14)	(2.41)	(2.75)
Number of households	1585	1800	1416

Note: Data come from rural households in the China Health and Nutrition Survey (CHNS) Household Survey in 1989, 2000, and 2009. Income and consumption are reported in 2009 US dollars (USD). The omitted occupation category is "other". Standard deviations in parentheses.

excludes private transfers to allow for the fact that private transfers may be a source of insurance. On the other hand, any insurance from income-smoothing based on the purchase or sale of assets (e.g., livestock) will remain in our income measure because we cannot separate out such behavior in our data.[20] The average annual household income excluding private transfers increased threefold,

[20]With income smoothing, measured changes in income would not only capture shocks, but also income-smoothing responses to such shocks, and thus the interpretation of our insurance results is insurance above and beyond any

from \$1,110 to \$4,011 (in 2009 USD). Comparing that to the total income, we observe that private transfers on average only account for less than 3% of total income.[21]

Our measure of consumption is household food consumption, constructed based on food consumption diaries whose quality and detail are suitable for the study of nutrition. Importantly, we measure the value of the food that was *actually* consumed as opposed to money spent on purchasing food. This distinction is important because rural households may produce food for own consumption, rendering expenditure an incomplete measure of consumption.[22,23] The annual food consumption measure increased from \$969 in 1989 to \$1,662 in 2009, a 72% increase over 20 years. The overall consumption measure grows at a similar magnitude, by 76%, over the sample period.[24]

Table 2 reports village-level statistics from the Community Survey. The average village population increased slightly from 2,193 households in 1989 to 2,697 households by the end of the sample period. The average area of a village is three square kilometers. Similar to the patterns in Figure 1 using Statistical Yearbook data, the CHNS data shows a decline in agriculture and a notable decline in collective TVEs. Moreover, while around 60% of rural Chinese farmland in our sample is irrigated (another form of income smoothing, see Mazur (2023)) and that is fairly constant over our sample period, a decreasing fraction is irrigated collectively (i.e., irrigated using village infrastructure), providing further evidence of a decline in collective agriculture. Conditional on the presence of collective TVEs, there was a slight decline in whether these TVEs help fund public goods in the community (e.g., housing, health and education, infrastructure, and pensions), but as a fraction of TVE revenue there is no obvious trend in funding. Given the decline in collective TVEs, however, unconditionally there was a strong decline in public funding from collective TVEs. Finally, in contrast to the decline in agriculture and collective TVEs, there was a large increase in

income smoothing that may also be taking place.

[21] See Appendix E for an analysis of private transfers given and received, which include cash or the value of in-kind gifts given to and received by family and friends.

[22] Appendix A.4.1 of Santaeulàlia-Llopis and Zheng (2018) cross-validates a measure of food expenditure that is consistent with the definition in the China Statistical Yearbooks.

[23] In Appendix F.2, we report results using an alternative household consumption measure, which includes in addition to food a limited number of non-food consumption goods such as utilities, health related expenditures, electronics, and kitchenwares. Since the consumption measure is predominantly, or over 90%, food, the results there are very similar to the baseline results.

[24] The CHNS does not directly ask about savings, but to the extent that the difference between income and consumption provides a crude measure of savings (net of private transfers), these summary statistics imply an increase in savings. Thus, the interpretation of the decline in insurance we find in the next section is a decline despite having a higher potential for self-insurance.

private enterprises and migrants from our sample of villages.[25]

Table 2: Summary Statistics, CHNS Community Survey, 1989-2009

	1989	2000	2009
Average population	2193	2051	2697
	(1846)	(1651)	(2280)
Median area (square kilometers)	3	3	3
	(40)	(95)	(31)
Percent of villages with farmland	91.23	70.37	70.83
	(28.41)	(45.83)	(45.61)
Percent of population in agriculture	55.71	58.57	47.22
	(26.89)	(27.57)	(30.13)
Percent of farmland irrigated (cond.)*	63.02	58.18	61.22
	(31.78)	(36.80)	(39.22)
Percent collectively irrigated (cond.)*	39.68	30.76	22.85
	(40.47)	(40.81)	(37.95)
Percent of villages with TVEs	62.50	37.78	14.58
	(48.62)	(48.66)	(35.42)
Number of TVEs in village	4.68	1.33	0.44
	(11.54)	(2.33)	(1.65)
TVEs pay for public goods (cond.)**	73.02	65.85	62.50
	(44.74)	(48.01)	(49.45)
Percent of TVE revenue spent on public goods (cond.)**	33.36	48.20	36.37
	(32.65)	(38.78)	(31.30)
Number of private enterprises in village*	10.35	9.31	29.33
	(23.75)	(27.04)	(43.06)
Migrants as percent of workforce	20.39	28.44	30.87
	(20.73)	(22.55)	(24.34)
Number of villages	121	140	144

Note: Data come from rural villages in the China Health and Nutrition Survey (CHNS) Community Survey in 1989, 2000, and 2009 that correspond to the villages in the Household Survey. Standard deviations in parentheses. *: values in the 1989 column correspond to 1991 values because the corresponding survey question was only asked starting in 1991. **: values in the 1989 column correspond to 1991 values and values in the 2009 column correspond to 2006 values because the corresponding survey question was only asked from 1991-2006.

5 Empirical Results on Changes in Risk Sharing over Time

In this section, we present the results based on the risk sharing models described in Section 3 using the data described in Section 4. In following the conceptual framework we sketched, we start with tests of perfect risk sharing and then move to estimates that quantify the extent to which different components of income shocks are reflected into consumption.

[25]Migrant workers are defined as individuals who worked out of town for more than one month in the past year.

5.1 Tests of Full Consumption Insurance

We first conduct tests of full consumption insurance, in the spirit of Townsend (1994). In particular, we first estimate equations (6) and (7) in Table 3, which test perfect risk sharing *within* villages. As mentioned above, these two equations have different power to capture different deviations from perfect risk sharing, with equation (6) giving more weight to permanent shocks to idiosyncratic income, while equation (7) better captures transitory shocks to income. Columns (1) and (3) report the estimates of equations (6) and (7) for the entire period. The results show that, although perfect risk sharing is formally rejected, households within villages are able to smooth most of idiosyncratic shocks. The specification in levels indicates that a 10% increase in household income is associated with a 0.74% increase in household consumption. The specification in first differences in column (3) indicates that a 10% change in income growth is reflected in 0.5% change in consumption, indicating minor differences between the effect of permanent and transitory shocks.[26]

Table 3: Tests of Full Consumption Insurance within Villages

	Log household food		Change in log household food	
	(1)	(2)	(3)	(4)
Log household income	0.074***			
	(0.010)			
Log household income x pre-1998		0.038***		
		(0.010)		
Log household income x post-1998		0.102***		
		(0.013)		
Change in log household income			0.052***	
			(0.011)	
Change in log household income x pre-1998				0.018
				(0.012)
Change in log household income x post-1998				0.073***
				(0.013)
P-value of difference in coefficients, pre-post		0.000		0.000
Observations	13146	13146	9398	9398
R-squared	0.641	0.642	0.308	0.309

Note: Regressions in columns (1) and (2) correspond to the levels specification in equation (6), use household level income and food consumption, control for village-year fixed effects and household fixed effects, and standard errors (in parentheses) are clustered by village. Regressions in columns (3) and (4) correspond to the first-differences specification in equation (7), use changes in household income and food consumption, control for village-year fixed effects, and standard errors (in parentheses) are clustered by village. P-value row reports the p-value of differences between the coefficient on the income variable interacted with pre-1998 and the coefficient on the income variable interacted with post-1998. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[26]Similar pass-through rates are found in other settings during roughly the same time period, such as Thailand (Kinnan, 2022), India (Morten, 2019), and southern China (Jalan and Ravallion, 1999).

Columns (2) and (4) interact log income and its change with two sub-periods: 1989-1997, which was marked by relatively stronger public good provision and relatively low growth (as discussed in Section 2), and 1998-2009, which was marked by more rapid growth and declining local public good provision. The results show that households were much better insured in the earlier period (in column (4) we cannot reject full insurance in the pre-period), while consumption insurance eroded in the later period.

Table 4 examines insurance against shocks that are aggregate to villages by reporting estimates of equations (8) and (9), using province-year fixed effects instead of year fixed effects given the size of rural China. Similarly to the findings on insurance against idiosyncratic shocks, these results suggest that insurance against aggregate shocks has also eroded over time: a 10% increase in average household income is associated with a 0.93% increase in average household consumption (column 1), with a similar coefficient on average household income growth (column 3). Moreover, columns (2) and (4) show an erosion of insurance over the two sub-periods (and again we cannot reject full insurance in the pre-period). In the level specification, a 10% increase in average household income has a negligible impact on average household consumption in the early period, while it is associated with a 1.4% increase in average household consumption in the second period. A similar pattern is found in the first differences specification, though these estimates are imprecise.

5.2 Partial Insurance Results

Using the tests developed in Section 3.2, we next quantify the extent to which different components of income shocks are responsible for the lack of perfect insurance both within and across villages documented in the previous subsection.

The Income Process. The income parameter estimates for each sub-period are found in Panel A of Table 5 along with the transmission parameters. Since the variance of measurement error in income is not separately identified from the variance of transitory idiosyncratic shocks, we set it to 0.05 but also show that alternative values of 0.01 and 0.1 have minimal effects on the estimates of other income parameters in Appendix F.1.[27] In particular, the estimates of the variance of the

[27]Without such assumptions, only the lower bound of the transmission of transitory shocks to consumption can be identified in the presence of (unidentifiable) income measurement error (Meghir and Pistaferri, 2004; Blundell, Pistaferri, and Preston, 2008).

Table 4: Tests of Full Consumption Insurance across Villages

	Average log household food		Change in average log household food	
	(1)	(2)	(3)	(4)
Average log household income	0.093***			
	(0.019)			
Average log household income x pre-1998		0.025		
		(0.039)		
Average log household income x post-1998		0.140***		
		(0.032)		
Change in average log household income			0.065*	
			(0.034)	
Change in average log household income x pre-1998				0.035
				(0.038)
Change in average log household income x post-1998				0.079
				(0.048)
P-value of difference in coefficients, pre-post		0.072		0.505
Observations	1084	1084	916	916
R-squared	0.650	0.654	0.270	0.271

Note: Regressions in columns (1) and (2) correspond to the levels specification in equation (8), use household level income and food consumption averaged at the village level, control for village and province-year fixed effects, and standard errors (in parentheses) are clustered by province. Regressions in columns (3) and (4) correspond to the first-differences specification in equation (9), use changes over time in average household level income and food consumption aggregated to the village level, control for province-year fixed effects, and standard errors (in parentheses) are clustered by province. P-value row reports the p-value of differences between the coefficient on the income variable interacted with pre-1998 and the coefficient on the income variable interacted with post-1998. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

permanent shocks, which are economically more relevant, are robust to alternative measurement error settings.

The results are similar across the two periods, suggesting that the volatility of income shocks did not change dramatically: Panel B shows that the only significantly different income variance over the two periods is the idiosyncratic transitory shock.[28] Transitory shocks are predominantly idiosyncratic, with the village-aggregate transitory shocks accounting for only about 10% of the total variance of transitory shocks, and hence the majority (90%) of transitory shocks are insurable within the village. This suggests a large scope for within-village risk sharing for transitory shocks. Around 50% to 60% of permanent shocks to households are idiosyncratic, and hence potentially insurable by a within-village risk sharing network. The remaining 40% to 50% of the permanent shocks, on the other hand, impact the entire village and would require insurance from outside of the village.

What are these various types of shocks? Examples of idiosyncratic shocks include household-

[28]This increased volatility for idiosyncratic transitory shocks could be due to higher rates of migration (which is often risky) as well as higher rates of private enterprises and wage work (which may have smoother incomes while in the job but higher rates of job loss).

Table 5: Estimates of Partial Insurance Model

	Permanent shocks		Transitory shocks	
	Idiosyncratic	Village-aggregate	Idiosyncratic	Village-aggregate
Panel A: Parameter estimates				
1989-1997 period				
Income variance	0.027^{**}	0.026^{***}	0.320^{***}	0.031^{***}
	(0.012)	(0.005)	(0.027)	(0.007)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.042	0.018	0.000	0.000
	(0.029)	(0.079)	(0.003)	(0.252)
1998-2009 period				
Income variance	0.034^{***}	0.024^{***}	0.389^{***}	0.043^{***}
	(0.011)	(0.005)	(0.028)	(0.008)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.120	0.619^{***}	0.041^{*}	0.000
	(0.101)	(0.231)	(0.022)	(0.284)
Panel B: χ^2 test of differences over time				
Income variance	0.35	0.16	5.69^{**}	1.52
	(0.55)	(0.16)	(0.02)	(0.22)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.58	5.09^{**}	3.57^{*}	0.00
	(0.45)	(0.02)	(0.06)	(1.00)
Joint test, income		13.93^{***} (0.01)		
Joint test, transmission		17.31^{***} (0.00)		

Note: Also estimated are food consumption heterogeneity and food consumption measurement error, both for the pre-period and post-period (not shown). Income measurement error is set to 0.05. Panel A: Standard errors in parentheses are based on 50 block bootstrap replications, clustered by village. Panel B: p-values of χ^2 test in parentheses. The joint tests are of all 4 pairwise comparisons for the respective parameter grouping. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

specific shocks like illnesses or family composition changes, accidents to property, or agricultural shocks that randomly affect some households and not others (e.g., localized pest issues). The extent to which these are permanent or transitory depends on whether the shock persists long-term (e.g., a chronic health condition) or is a one-time shock (e.g., pests). Examples of village-aggregate shocks include agricultural shocks that affect all households (e.g., drought), changes to the overall productivity of a village (e.g., completion of a road-building project), or macroeconomic fluctuations that could affect sale prices of goods produced in the village.

The Transmission of Shocks. Panel A of Table 5 also reports the transmission parameters from equation (12) of the partial insurance model, using food as the consumption measure.[29] In the 1989-1997 sub-period, each of the transmission parameters is small and statistically insignificant. Even the largest transmission parameter estimate, $\hat{\delta_I} = 0.042$, suggests that only 4.2% of a permanent idiosyncratic change in income passes through to household consumption, which means that most of such an income shock is smoothed out. This is consistent with the small transmission rates of idiosyncratic income shocks to consumption in Section 5.1 (the results in Section 5.1 are statistically significant, but mostly because the estimates are more precise). It is also consistent with the findings of Santaeulàlia-Llopis and Zheng (2018) that cannot reject the null of perfect insurance in rural China in the 1990s.

In the 1998-2009 period, however, this changes: the transmission of the idiosyncratic transitory shock and of the village-aggregate permanent shocks become significantly positive (and significantly different from the transmission parameters in the earlier period, as Panel B shows). The transmission of the idiosyncratic transitory shocks is a low yet significant 0.041, while the transmission of the village-level permanent shocks is a significant 0.619. Now a 10% decline to village-level permanent income leads to a 6.2% decline in household consumption, a much higher pass-through of income shocks to consumption. Thus, despite the fact that some of the coefficients are noisy, the overall increase in the various transmission coefficients points to a decline in insurance, consistent with the results in the earlier section.

There are several potential underlying mechanisms for these transmission results. Transitory shocks are relatively easy to smooth through savings (either by households themselves or by village

[29] Appendix Table 9 reports the estimates for the household total consumption measure, which are very similar.

funds), which likely explains their low pass-through in both the earlier and later periods. Permanent shocks, however, are more difficult to smooth through savings. Nevertheless, households managed to achieve a large degree of partial insurance against some permanent shocks through other mechanisms, including risk sharing within a village as well as across villages.[30] The organization of a village can be more or less conducive to risk sharing: for example, collective TVEs and agricultural collectives are built-in mechanisms that provide transfers across households within the village. On the other hand, such risk sharing may be weaker in a village with a smaller presence of such institutions or with better outside opportunities for households, like migration opportunities. Villages cannot, however, easily insure against shocks that are aggregate to the village, and thus such shocks are more easily insured via transfers from higher levels of government such as county or provincial governments.

We dive deeper into these mechanisms in Section 6, but Table 5 also sheds light on them. First, the lack of insurance against village-aggregate permanent shocks in the 2000s marks a striking departure from the earlier period (as seen in the change of the transmission parameter from 0.018 in the earlier period to 0.619 in the later period), suggesting a weakening of insurance from higher levels of government. Second, the fact that idiosyncratic shocks became less insured is suggestive of some breakdown of village risk-sharing, which is consistent with a weakening of the collective organization of villages over the time period of study. Nevertheless, within-village risk sharing was still an important source of partial insurance against idiosyncratic risk for households. To quantify the insurance provided from within the village, we compare the transmission of idiosyncratic risk with that of village-aggregate risk. Intuitively, villagers have one more source of insurance, i.e. from their fellow villagers, to insure against an idiosyncratic shock than against a village-aggregate shock. From 1998 to 2009, the transmission of the idiosyncratic permanent shock was 0.12, meaning that 88% (1-0.12) of the shock is smoothed, while that of the village-aggregate permanent shock was 0.62, meaning that only 38.1% (1-0.619) of the shock is smoothed. Because village insurance networks can help smooth idiosyncratic shocks but not aggregate shocks, the difference in the

[30] An alternative hypothesis is that advance information about shocks could be biasing downward the transmission parameters, because if households know of shocks in advance, consumption would react before the shock realized, and thus consumption growth at the time of the realization of the shock would not be affected. To test this, we regress unexplained consumption growth on one-period ahead unexplained income growth, in which a positive coefficient suggests advance information. We estimate a coefficient of 0.003 and a standard error of 0.008, suggesting no evidence of advance information.

two transmission parameters suggests that village insurance networks help smooth 49.9% (i.e., 100*(0.619-0.12)) of permanent idiosyncratic shocks.[31]

The Welfare Costs of the Decline in Insurance. We next use the results from Table 5 to quantify the welfare loss related to the documented changes in risk and insurance, and decompose the welfare loss into idiosyncratic and village-aggregate components. In particular, we compute the percentage change in annual consumption across all states of the world for a household to be indifferent between the baseline (1989-1997) period and a counterfactual risk or insurance environment, holding baseline income constant (i.e., not accounting for the welfare effects of growth). To do this, we assume CRRA utility and derive analytical formulas for consumption equivalents (see Appendix D for the derivation). This exercise is similar to the welfare calculations in Santaeulàlia-Llopis and Zheng (2018), but they focus on welfare changes from growth, risk, and insurance overall, while we focus on decomposing the insurance effect on welfare into its idiosyncratic and village-aggregate components.

Table 6 reports the welfare effects for risk aversion coefficients of $\eta = 2$ and $\eta = 4$. The first row reports the welfare loss, as a percentage change in consumption, of moving from the income risk of the 1989-1997 period to the income risk of the 1998-2009 period, holding insurance parameters constant. This welfare loss is close to zero. While income risk increased over the period, it was mainly idiosyncratic transitory risk, which is relatively well insured and thus this risk does not generate large welfare effects. The second row reports the welfare loss of moving from the insurance environment in the 1989-1997 period to the insurance environment in the 1998-2009 period, holding income risk parameters constant. The change in insurance over the time period had a much larger effect on welfare, ranging from a 0.5 percent consumption loss to a 1.6 percent consumption loss depending on the level of risk aversion.[32] These risk and insurance effects are in line with the findings in Santaeulàlia-Llopis and Zheng (2018) for rural China.

The remaining rows of Table 6 decompose the insurance effect into the effect from the decline in insurance against idiosyncratic risk and the decline in insurance against village-aggregate risk. For both levels of risk aversion, the main driver of the insurance effect by a large margin is the

[31] Transitory shocks are still well insured even at the aggregate level, and thus there is less need for village insurance networks to smooth idiosyncratic transitory shocks (the analogous percent insured by the village is a noisy zero).

[32] Note that the risk and insurance effects don't linearly add to the total effect in the final row. For them to add up, we would have to instead compute the insurance effect above and beyond the risk effect.

erosion of insurance against village-aggregate shocks.

Table 6: Welfare Effects of the Change in Risk and Insurance

	$\eta = 2$	$\eta = 4$
Risk effect	-0.001%	-0.002%
Insurance effect	-0.54%	-1.61%
Idiosyncratic effect	-0.04%	-0.13%
Village-aggregate effect	-0.50%	-1.48%
Village-aggregate as % of insurance effect	0.92	0.92
Total effect	-0.51%	-1.53%

Notes: This table shows the effects of changes in risk and insurance over the sample period on welfare as a percentage of annual consumption. The first column reports effects for a CRRA utility function with a coefficient of two, and the second column with a coefficient of four. See Appendix D for the welfare derivations.

In sum, our analysis reveals that rural households in China faced significantly higher levels of idiosyncratic transitory risk over our sample period coupled with a decrease in the households' ability to insure against it. Moreover, while permanent risk remained constant throughout the sample period, there was a considerable loss of insurance against aggregate permanent risk. In the next section, we examine the factors that may lie behind the deterioration of both within-village and across-village risk-sharing.

6 Mechanisms behind the Decline in Insurance

In this section, we provide suggestive evidence that sheds light on the mechanisms underlying the two main findings in Section 5.2 that insurance against both idiosyncratic and aggregate shocks has eroded over time. First, we exploit provincial variation in rural village characteristics, including the size of the agricultural sector, the prevalence of collective TVEs, and the rate of migration, to further investigate the narrative that the loss of consumption insurance against idiosyncratic shocks was associated with a departure from rural China's collective past that had previously tied villagers' lives together, reduced potential information asymmetries, and involved high costs of breaking commitment to one's village. We also use county-level fiscal variation to examine the narrative that the loss of insurance against village-aggregate shocks was associated with the changes of inter-governmental allocation of funds.

6.1 The Weakening of Within-Village Insurance

Theoretically, there are a number of frictions that prevent perfect risk sharing (either with informal networks or with formal markets), including imperfect enforceability of contracts or limited commitment (Kocherlakota, 1996; Ligon, Thomas, and Worrall, 2002), imperfect information, and moral hazard (Cole and Kocherlakota, 2001; Attanasio and Pavoni, 2011). As environments change to include alternative opportunities, institutions, and resources, so do the frictions that determine the level of informal insurance that an informal network or market-based insurance can sustain. For example, Morten (2019) and Meghir, Mobarak, Mommaerts *et al.* (2021) show that increased opportunities to migrate can help or hinder informal risk-sharing, depending on the riskiness of migration, and Ábrahám and Laczó (2018) show that a decline in the availability of a public storage technology (like a TVE) hinders the level of informal risk-sharing.

As discussed in Section 2, our sample period captures a period of major economic transformation in rural China, including the transition out of agriculture, the decline of the collective TVEs, and an increase in rural-urban migration (see Figure 1 for national patterns and Table 2 for patterns in our analysis sample). To examine the link between consumption insurance and these changing local characteristics, we estimate the extent to which the correlation between household income and food consumption (ψ in equation (6)) varies by three village characteristics aggregated to the province level:[33] (1) the average percent of the village population working in agriculture, (2) the average percent of the village population engaged in migration, and (3) the percent of villages with collective TVEs. Denoting these characteristics by X_{pt} we interact them with log income and an indicator for the pre-1998 period and post-1998 period in a Townsend-style specification similar to equation (6):

$$\begin{aligned} c_{ivpt} = \quad & \psi_1 \cdot y_{ivpt} \cdot \mathbf{1}_{t\leq 1997} + \zeta_1 \cdot y_{ivpt} \cdot X_{pt} \cdot \mathbf{1}_{t\leq 1997} \\ & + \psi_2 \cdot y_{ivpt} \cdot \mathbf{1}_{t\geq 1998} + \zeta_2 \cdot y_{ivpt} \cdot X_{pt} \cdot \mathbf{1}_{t\geq 1998} + \tilde{\pi}_{ivp} + \nu_{vpt} + \varepsilon_{ivpt} \end{aligned} \tag{13}$$

In the above, c_{ivpt} and y_{ivpt} are log annual consumption and income of household i in village v in province p in year t, $\tilde{\pi}_{ivp}$ are household fixed effects, and ν_{vpt} are village-year fixed effects. We

[33] These characteristics are reported at the village level in the CHNS Community Survey. Unfortunately, there is very little household-level information on migration to investigate these mechanisms further.

allow the coefficients ψ_j and ζ_j to vary by pre-1998 ($j = 1$) and post-1998 ($j = 2$). We stress that these are household-level (as opposed to village-average) regressions, and because we control for aggregate village resources through the village-year fixed effects, we interpret the results of these specifications as tests of *within*-village consumption insurance (i.e., tests of insurance against idiosyncratic risk to households).

Table 7: Consumption Smoothing, Interacted with Provincial Characteristics

	Log household food consumption				
	(1)	(2)	(3)	(4)	(5)
Log household income x pre-1998	0.038***	0.037	0.050	0.057**	0.088
	(0.010)	(0.058)	(0.040)	(0.028)	(0.111)
x Province avg agriculture		0.000			-0.000
		(0.001)			(0.001)
x Province avg migration			-0.001		-0.001
			(0.002)		(0.002)
x Province avg collective enterprises				-0.000	-0.000
				(0.001)	(0.001)
Log household income x post-1998	0.102***	0.237***	-0.021	0.141***	0.169**
	(0.013)	(0.046)	(0.046)	(0.021)	(0.080)
x Province avg agriculture		-0.003***			-0.002**
		(0.001)			(0.001)
x Province avg migration			0.004***		0.002
			(0.002)		(0.002)
x Province avg collective enterprises				-0.002**	-0.001**
				(0.001)	(0.001)
Mean interacted variable, pre-1998		59.23	20.07	56.62	
SD interacted variable, pre-1998		12.52	5.762	17.69	
Mean interacted variable, post-1998		50.77	29.97	21.41	
SD interacted variable, post-1998		14.21	7.606	15.74	
F-stat, pre-1998 interactions					0.155
F-stat, post-1998 interactions					5.819
Observations	13146	13146	13146	13146	13146
R-squared	0.642	0.643	0.642	0.642	0.643

Note: Each column is a separate regression of log household food consumption on log household income interacted with pre-1998 and post-1998, and in columns (2)-(5) also interacted with provincial averages of village economic conditions. Means and standard deviations of the interacted variables in columns (2)-(4), and F-stats of the interaction terms by pre/post in column (5), are in the lower panel of the table. Standard errors in parentheses are clustered by village. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results are reported in Table 7. The first column corresponds to the second column in Table 3 and shows that within-village insurance is incomplete and deteriorates over time. The remaining columns interact log income with village characteristics (one by one in columns (2) through (4) and altogether in the final column). In the pre-1998 period, these characteristics are not correlated with household-level insurance. In contrast, these characteristics become highly

correlated with insurance in the post-1998 period. Column (2) shows that households are better insured against income shocks by villages in provinces where a higher share of the village population works in agriculture, while column (3) shows that households are more poorly insured by villages in provinces where a higher share of the village population engages in migration. Column (4) shows that households are also better insured by villages in provinces with a larger presence of collective TVEs.[34] Finally, column (5) shows that these effects largely persist in tandem (the p-value of the F-statistic in the post-1998 period is $p < 0.01$).

The transition out of agriculture, the increase in migration, and the dissolution of collective TVEs were prominent features of the economic transformation of rural China (Section 2), and the results in Table 7 suggest that within-village insurance against household-level income risk declined most where these changes were most marked. This is consistent with the broad patterns of transitions out of agriculture and collective enterprise and into private enterprise that did not have built-in community insurance mechanisms. In contrast, when we repeat this exercise using consumption and income averaged to the village level (Appendix F.4), we find that these characteristics are not as relevant for insurance *across* villages. This is perhaps not surprising, given that any mechanism that helps share risk across villages must entail moving resources across villages, which is likely coordinated at a higher level. This motivates us to investigate the role of inter-governmental transfer programs in the decline of insurance against village-aggregate risk.

6.2 The Weakening of Across-Village Insurance

The governmental administrative system in rural China today is multi-layered: from bottom up are villages, townships, counties, prefectures and provinces, with the latter two layers combining both rural and urban localities. Prior to the 1994 Tax Reform, townships had substantial fiscal power (in part stemming from the proliferation of collectively owned TVEs, as discussed in Section 2) and shouldered considerable fiscal responsibilities for its residents, including providing health services, education, and social insurance. With the 1994 Tax Reform, however, fiscal power was

[34] An interesting question is whether informal sources of insurance responded to these changes in formal sources of insurance. We test this by running analogous regressions of net private transfers on household income (both in levels instead of logs since net transfers can be negative) in Appendix Table 4. We find that a 1 yuan increase in household income corresponds to a decrease in transfers received of 0.02 yuan, which is consistent with this story that as insurance provided by local public institutions (such as TVEs) declined, informal risk sharing increased in response – though not enough to offset the decline.

recentralized without reassigning fiscal responsibilities, thus leaving many townships paralyzed by fiscal imbalance.

The formal remedy set up by the central government was a new inter-governmental transfer system from county-level governments up, whereby fiscally rich localities could transfer resources to fiscally poor localities. In particular, "general transfer" programs were originally meant to provide long-term periodic funds aimed at geographical redistribution and risk-sharing so that funds flow to localities whose fiscal gap, i.e. the difference between expenditures and revenues, are higher than the national average (Shen, Jin, and Zou, 2012). In contrast, "special transfer" programs provide ad hoc transfers to facilitate specific central policies, such as subsidies for agricultural development, support for infrastructure construction, and natural disaster relief funds. In principle, both types of transfer programs can provide insurance (e.g., severe flooding could trigger relief funds from the special transfer program as well as funds from the general transfer program to offset heightened fiscal needs as a result of the flooding). In practice, however, previous literature finds that these programs have had a negligible (if not negative) impact on the goal of equalizing fiscal gaps (see, e.g., Tsui (2005) and the review in Shen, Jin, and Zou (2012)).[35]

To investigate the role of intergovernmental transfers on insurance against aggregate shocks with our framework and data, we exploit a panel of county-level fiscal revenue and expenditure measures for all counties in China from 1994-2007 merged with county-level output measures.[36] Ideally we would observe how more local levels of government transfer resources in response to local shocks, but fiscal accounts are only systematically reported from county governments upwards and thus we can only observe flows between county-level governments and the central government. To the extent that differences in fiscal transfers at the county level trickle down to more local levels, the following analysis speaks to insurance against shocks at the village, township, and county level.

Table 8 reports summary statistics at several points in time (converted to thousands of 2009 US

[35]One explanation is that the general transfer program was increasingly used to promote political stability as opposed to equity since its inception. Wang (2003) found that higher transfers were given to localities with higher risk of social unrest and higher shares of minorities, even though they were not the most fiscally disadvantaged localities.

[36]Our data is from *EPS China Statistics*, which provides proprietary databases that integrate official data published by various levels of government and various governmental agencies in China. We use the China Fiscal and Taxation Database — Financial and Economic Statistics at the City and County Level sub-database. This database contains annual data of revenues and expenditures of the general budget and special funds of counties with 100 million yuan and above in fiscal revenue. We supplement the data with the China Regional Economy Database for other county-level macro statistics such as output and population.

dollars) for output, total fiscal revenue and expenditure, local tax revenue and local expenditure, and general and special transfers received and contributed. Revenue and expenditure both increase substantially between 1994 and 2007 despite the average county population staying relatively constant over the period. In particular, general transfers have increased dramatically from comprising 4.4% of total revenue in 1994 to 27% of total revenue in 2007. These patterns suggest that local governments rely on their own tax revenue to a large extent, but over time a larger and larger portion of local governments' budgets are obtained through the transfer programs.

Table 8: Summary Statistics, Fiscal Balance Sheet of Counties

	1994	1997	2002	2007
Output (1,000s 2009 USD)	2,903	3,290	4,978	11,003
	(3,087)	(3,597)	(5,438)	(13,261)
Total fiscal revenue (1,000s 2009 USD)	177	230	423	1,153
	(156)	(206)	(388)	(1,047)
Tax revenue (%)	72.8	70.8	58.1	50.9
General transfers received (%)	4.4	3.4	23.3	27.1
Special transfers received (%)	14.7	13.8	12.0	17.1
Other revenue (%)	8.2	12.0	6.7	4.9
Total fiscal expenditures (1,000s 2009 USD)	187	230	433	1,100
	(163)	(202)	(388)	(980)
Local expenditures (%)	79.7	82.8	91.3	93.3
General transfers contributed (%)	13.5	6.9	3.9	2.7
Special transfers contributed (%)	2.4	2.9	4.3	3.9
Other expenditures (%)	4.4	7.3	0.5	0.1
Population (10,000s)	43	44	45	48
	(39)	(38)	(33)	(35)
Number of unique counties		3,082		
Number of county-year observations		39,553		

Note: This table reports means outside of parentheses and standard deviations in parentheses of output, total fiscal revenue, total fiscal expenditures, and population from the county-level panel. Output, total fiscal revenue, and total fiscal expenditures are reported in thousands of 2009 US dollars. The components of revenue and expenditures are reported as a fraction of the total. Details of sample construction are found in Appendix A.2.

To quantify the extent to which inter-governmental insurance against local aggregate shocks has changed over time, we follow a similar Townsend-style regression approach as in earlier sections of the paper but use aggregate output as our measure of local aggregate shocks and fiscal measures as our measures of aggregate "consumption". Specifically, we run the following regression:

$$F_{cpt} = \gamma_1 Y_{cpt} \cdot \mathbf{1}_{1994 \leq t \leq 1997} + \gamma_2 Y_{cpt} \cdot \mathbf{1}_{1998 \leq t \leq 2007} + X_{cpt}\delta + \alpha_{pt} + \beta_{cp} + \varepsilon_{cpt} \tag{14}$$

where F_{cpt} is a fiscal measure in county c in province p in year t, Y_{cpt} is county output in year t,

X_{cpt} is county population in year t, and β_{cp} and α_{pt} are county fixed effects and province-year fixed effects, respectively. γ_1 and γ_2 capture the potentially differing effects of output on F_{cpt} for the earlier time period (1994-1997) and later time period (1998-2007) to best correspond to the time periods of the earlier analyses.

Table 9: Effect of County Output on Components of County Fiscal Income and Expenditures

	(1) Tax revenue	(2) Net gen. transf.	(3) Net spec. transf.	(4) Local expenditure
Output, 1994-1997	0.020***	-0.027**	-0.001*	0.013***
	(0.002)	(0.012)	(0.000)	(0.003)
Output, 1998-2007	0.036***	-0.004***	-0.000	0.034***
	(0.002)	(0.001)	(0.000)	(0.002)
Mean output, pre-1998	3129.8	2829.5	3293.2	3129.6
SD output, pre-1998	3305.3	1955.6	3333.3	3309.9
Mean output, post-1998	5861.9	10022.4	6311.1	5846.8
SD output, post-1998	7334.2	10058.3	7648.9	7349.9
Observations	31700	7434	27011	32132
R-squared	0.922	0.906	0.763	0.942

Note: Data comes from 1994-2007 EPS China Statistics. Column (2) contains fewer observations because general transfer data is missing for some years and some counties. All regressions control for county population, county fixed effects and province-year fixed effects. Output means and standard deviations are reported in thousands of 2009 US dollars. Standard errors in parentheses are clustered by county. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9 reports the γ coefficients from Equation (14) for outcomes including tax revenue, local expenditures, net general transfers, and net special transfers.[37] The first column shows that a \$100 increase in output corresponds to a \$2.0 increase in tax revenue in the early period and a \$3.6 increase in tax revenue in the later period. The difference in these estimates suggests that local governments keep a higher percentage of their output in later periods. Similarly, the second and third columns show that counties with higher output receive lower net general transfers and net special transfers, but this negative correlation is less prominent in the later period. The final column shows a similar pattern as the first column: the more output generated by a county, the higher the local expenditures. All differences in coefficients are statistically significantly different from each other except for special transfers.

These results suggest that county governments are increasingly self-reliant to satisfy their fiscal spending needs, leaving counties which are hit by bad economic shocks increasingly vulnerable.

[37] Because net general transfers and net special transfers can be negative, we run all four specifications in levels instead of logs.

While these results may be subject to reverse causality concerns (government revenues and expenditures may affect local output through investment incentives, for example), the evidence for declining within-province insurance across counties corroborates the declining within-province insurance across villages observed in Table 5 and findings in the literature that general transfer programs are increasingly used for purposes other than insurance (Wang, 2003). In sum, the results of the fiscal analysis in this section provide further evidence that insurance against village-aggregate shocks has deteriorated over time, as shown by the decline in responsiveness of county fiscal measures to output changes.

7 Conclusion

We quantify the degree of village insurance in a growing China with changing institutions, taking care to distinguish between permanent and transitory income shocks as well as between household-level idiosyncratic shocks and village-level aggregate income shocks. We observe an overall deterioration in consumption insurance for rural households from 1989 to 2009, in particular against idiosyncratic transitory income risk and village-aggregate permanent income risk. Using variation in economic conditions across regions, we further document that lower levels of consumption insurance tend to arise in regions with smaller agricultural sectors, regions with higher levels of temporary migration, and regions with fewer public good contributing TVEs. We also provide suggestive evidence that the inter-governmental fiscal transfer programs put in place after the 1994 Tax Reform led to a decrease in insurance against shocks that impact the entire local community. With rising regional inequality, local governments are left to themselves for insurance, making village aggregate income risk increasingly difficult to insure.

There are several avenues for future work to build on this paper. First, one of the main goals of the Chinese reforms during the period of study was to introduce better incentives for work effort (such as the Household Responsibility System). While we abstract from the effects of these changes in incentives, a more thorough investigation of classic insurance-incentive trade-offs would be an interesting next step. Second, our empirical results are specific to the case of rural China over the 20 years of rapid economic growth before the post-global financial crisis slow-down. More recently, the focus of the central government has shifted towards rebalancing the economy and reducing

regional disparities. For example, a set of targeted poverty-alleviation programs was adopted in 2014 to help poor households in rural regions grow out of poverty, such as relocating entire villages (Zhang, Xie, and Zheng, 2023). These policies have the potential to once again increase the level of consumption smoothing at both the individual and village level and would be interesting for future study. Finally, while we believe these results are important for understanding one of the most impressive growth episodes in the world, they certainly do not apply to all countries along the development path. For example, countries that underwent other types of economic transformations (such as financial liberalization) may have experienced markedly different changes to consumption insurance. Fortunately, our framework is suitable to the study of consumption insurance in these other contexts. We leave these endeavors to future research.

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Appendix A Data and Sample Construction

A.1 Household-level data

The China Health and Nutrition Survey (CHNS) follows a multistage, random cluster process to draw the samples surveyed in each of the provinces. (Rural) counties in the nine provinces were stratified by income (low, middle, and high), and a weighted sampling scheme was used to randomly select four counties in each province. Two (urban) cities in each of the provinces were selected, with one being a large city (and often the provincial capital) and the other a lower-income city. Then, villages and towns within the counties and urban and suburban neighborhoods within the cities were selected randomly. These villages, towns, urban and suburban neighborhoods are called the primary sampling units (PSU). Within each PSU, about 20 households were selected randomly in 1989 and interviewed. Each household has been followed since, unless it moved out of the PSU, in which case no follow-ups were attempted. Instead, a replacement household from the same PSU was introduced to ensure a constant sample size.

Our starting point is the analysis sample of Santaeulàlia-Llopis and Zheng (2018) and we refer the reader to the Appendix therein for details of the procedure of variable construction. For our analysis, we construct an unbalanced panel of rural households in the following steps. Starting from the CHNS sample (which trims the top and bottom 1% of income and consumption distributions by wave), we keep the rural households, which leaves us about two-thirds of the initial sample. We drop households for whom we don't have information about the household size, the number of children in the household, the number of the elderly in the household, the age of the head, the gender of the head or the ethnicity of the head. We further drop households with missing (logged) income or consumption information. We keep households for which we have non-missing income from at least two consecutive waves. Appendix Table 1 documents the operations and effects of each step in the construction of our estimation sample.

A.2 County-level data

To construct the county-level sample, we extract data from the proprietary *EPS China Statistics* database. The main source of data is the China Fiscal and Taxation Database – Financial and Economic Statistics at the City and County Level sub-database. We extract from it fiscal income

Appendix Table 1: Sample Selection, CHNS, 1989 to 2009 (8 Waves)

Operation	No. of obs (HH × wave)
(Initial sample)	26,005
Keep if hh resides in a rural area	18,011
Drop if missing hh size, age, gender or minority status	17,832
Drop if missing education	17,832
Drop if missing (logged) income or food consumption	17,723
Keep if non-missing income from 2 consecutive waves	13,464

Note: This table reports the sample selection process we follow to construct the household-level panel of income and consumption.

(and its components) and fiscal expenditure (and its components), population and output, all at the county level from 1994 to 2007.[38] We also extract from the Chinese Macroeconomics sub-database the Consumer Price Index (CPI) at the province level from 1994 to 2007. We document the construction of main variables used in the analysis as follows.

Fiscal revenue and expenditure items The full fiscal balance sheet is translated into English in Appendix Table 3. As new items of transfer and spending are gradually introduced over time, the availability of the variables varies, which is also documented in the table. Whenever possible, we double check the consistency between the sum of sub-items and the item; when the item itself is missing, we replace it with the sum of its sub-items. We lump the annual revenues and returned revenues together and define the sum of the two to be the variable, *tax revenue*. The returned revenues were introduced in 1994 to ensure that provinces obtain at least as much VAT and consumption tax revenue as in 1993. More precisely, the returned revenue in 1994 was based on the gap between the local revenue under the new tax scheme and the local revenue in 1993, and thereafter the returned revenue grows annually at a rate of 0.3 times the growth rate of VAT and consumption tax in the province (Shen, Jin, and Zou, 2012). As a result, the returned tax is highly correlated with local tax revenue and does not perform a redistributive function as the general and special transfers we document below.[39] The variable, *general transfer received*, is

[38]The fiscal revenue and expenditure data are available from 1993 to 2009 while the output data are only available from 1993 to 2007. We exclude 1993 because the accounts are modernized following the 1994 Tax Reform, so the 1993 data is missing key variables such as the general transfer payments.

[39]In our sample, the correlation between local tax revenue and returned tax revenue is 0.85 in 1994 and 0.80 in 2009, and averages at 0.79 across all available years.

the sum of all items under the "General transfer payments income"; the variable, *special transfer received*, is the item "Special transfer payments"; and the rest of the items under "Total revenues" is summed up to form the variable, *other revenues*. On the expenditure side, the variable, *local expenditure*, corresponds to the item "Annual expenditures," which is the total spending on various public goods – education, public security, environmental protection, infrastructure and so on. The variable, *general transfer given*, is the item "General transfer payments," which is the sum of its two sub-items. The variable, *special transfer given*, corresponds to the item, "Special transfer over payments," while the rest of the items are summed up to form the variable, *other expenditures*. In the empirical analysis, we construct *net general (special) transfer* by subtracting from general (special) transfer received general (special) transfer given. We trim the main components of revenue and expenditure top and bottom 1% by year.

Output The three series of industrial gross output, agricultural gross output, and industry and agricultural gross output are available from 1993-2000, 1997-2000 and 1993-1996 respective. We sum up industry and agricultural outputs for 1997-2000, and form a series of industry and agricultural output from 1993-2000. The value added is available from 1997-2007. We use the overlapping years, 1997-2000, to regress log value added on log industry and agricultural output, and impute the value added for 1993-1996. This gives us a complete series of value added from 1993-2007, which is our variable, *output*.

Sample Selection We keep all observations from 1994 to 2007. We then replace all main variables by missing if the output growth from the previous year is greater than 2/3 or less than -2/3. We drop observations for which all of the following main variables are missing: tax revenue, net general transfer, net special transfer, local expenditure, output and population. Appendix Table 2 documents the operations and effects of each step in the construction of the county-level sample. This results in an unbalanced panel of 39,553 county-year observations. Finally, we deflate all economic variables by province-level CPI (2009=100) and transform them into 2009 US dollars by dividing the real values in Chinese *yuan* by 6.9477, which is the average exchange rate of USD against CNY in 2009. All economic variables are in thousand 2009 USD.

Appendix Table 2: Sample Selection, County-Level Fiscal Data, 1993 to 2007

Operation	No. of obs (county × year)
(Initial sample)	52,129
Keep if year is in between 1993 and 2007	42,901
Drop if all main variables are missing	39,553

Note: This table reports the sample selection process we follow to construct the county-level panel of fiscal income, expenditure, output and population.

Appendix Table 3: County Government Fiscal Balance Sheet

Items	Availability
Total revenues	1994-2009
Annual revenues	1993-2009
Returned revenues	1994-2002, 2007-2009
Consumption tax and VAT tax return	2003-2007
Income tax cardinality return subsidies	2002-2007
Export tax rebate cardinality return	2004
General transfer payments income	2007-2009
Institutional subsidies	1994, 1996-2007
General transfer payments subsidies	2002-2007
Transitional transfer payment subsidies	2001
Minority areas transfer payments	2001-2007
Rural tax reform subsidies	2002-2007
Primary and secondary school teachers transfer payments	2001-2006
Special agricultural products tax abolishment and agricultural tax rate reduced transfer payments subsidies	2004-2006
Counties and townships financial difficulties ease transfer payments subsidies	2005-2007
Rural compulsory education subsidies	2006-2007
Issuing treasury bonds subsidies	2000-2006
Wage adjusted subsidies transfer payment	2001-2007
Hard remote areas allowance subsidies	2001
Settlement subsidies	2000-2007
Enterprise budget transfer subsidies	2006-2007
Special transfer payments	1993-2009
Finance ministry issued local government bond lending revenues	2009
Prior year balances	1993-2009
Transferred funds	2000-2009
Adjusted revenue task increasing or decreasing subsidies	2000-2002
Agricultural tax relief and enterprises budget transfer	2003-2005
Other subsidies	2000-2006
Treasuries on-lending, prior year balances and turn subsidies	2003-2007
Others	1993-2002
Total expenditures	1994-2009
Annual expenditures	1993-2009
General transfer payments	2007-2009
Institutional over payments	1993-2007
Export tax rebates special over payments	2005-2007
Special transfer over payments	1993-2009
Arrangements for budget stabilization fund	2001-2009
Call-up funds	2000-2009
Separated planning to province over payments	2002-2007
Treasuries lending allocated number and the year-end balances	2003-2007
Others	1993-2002
Year end balances	1994-2009
Of which: net balance	1994-2009

Note: This table reports the items contained in the county fiscal balance sheet and the availability of each item in terms of years.

Appendix B Identification of the Partial Insurance Model

Identification of the model is similar to Attanasio, Meghir, and Mommaerts (2015), and involves a total of 20 parameters (10 for each sub-period, given that we only allow estimates of each type of parameter to vary by the two sub-periods): 8 income variances, 8 transmission parameters, 2 consumption measurement error variances, and 2 consumption heterogeneity variances. In this appendix we show identification, accounting for our non-consecutive data structure, of the income variances, then the consumption parameters, for a particular sub-period.

Income parameters

We first rewrite the growth over $\tau \geq 2$ years (denoted by Δ_τ) in log unexplained income as:

$$\Delta_\tau y_{i,v,t} \equiv y_{i,v,t} - y_{i,v,t-\tau} = \sum_{s=t-\tau+1}^{t} \left(u^V_{v,s} + u^I_{i,v,s} \right) + \Delta_\tau e^V_{v,t} + \Delta_\tau e^I_{i,v,t} + \Delta_\tau r^y_{i,v,t} \tag{15}$$

and define village-average income by aggregating this equation within a village:

$$\Delta_\tau \overline{y}_{v,t} = \sum_{s=t-\tau+1}^{t} u^V_{v,s} + \Delta_\tau e^V_{v,t} + \frac{1}{N_v} \sum_{i=1}^{N_v} \Delta_\tau r^y_{i,v,t} \tag{16}$$

We then use the following covariances for identification:

$$\text{cov}(\Delta_\tau y_{i,v,t}, \Delta_\tau y_{i,v,t}) = \tau \text{var}(u^I) + \tau \text{var}(u^V) + 2\text{var}(e^I) + 2\text{var}(e^V) + 2\text{var}(r^y) \tag{17}$$

$$\text{cov}(\Delta_\tau y_{i,v,t}, \Delta_\tau y_{i,v,t+\tau}) = -\text{var}(e^I) - \text{var}(e^V) - \text{var}(r^y) \tag{18}$$

$$\text{cov}(\Delta_\tau \overline{y}_{v,t}, \Delta_\tau \overline{y}_{v,t}) = \tau \text{var}(u^V) + 2\text{var}(e^V) + \frac{2}{N_v}\text{var}(r^y) \tag{19}$$

$$\text{cov}(\Delta_\tau \overline{y}_{v,t}, \Delta_\tau \overline{y}_{v,t+\tau}) = -\text{var}(e^V) - \frac{1}{N_v}\text{var}(r^y) \tag{20}$$

Since we set $\text{var}(r^y) = 0.05$, $\text{var}(e^V)$ is then identified from (20), and with that then $\text{var}(e^I)$ is identified from (18) and $\text{var}(u^V)$ is identified from (19). Finally, $\text{var}(u^I)$ is identified from (17).

Consumption parameters

Similar to income, we first rewrite the growth over τ years (denoted by Δ_τ) in log unexplained consumption as:

$$\Delta_\tau c_{i,v,t} \equiv c_{i,v,t} - c_{i,v,t-\tau} = \sum_{s=t-\tau+1}^{t} \left(\delta_I u^I_{i,v,s} + \gamma_I e^I_{i,v,s} + \delta_V u^V_{v,s} + \gamma_V e^V_{v,s} + \xi_{i,v,s} \right) + \Delta_\tau r^c_{i,v,t} \quad (21)$$

and define village-average consumption by aggregating this equation within a village:

$$\Delta_\tau \overline{c}_{v,t} = \sum_{s=t-\tau+1}^{t} \left(\delta_V u^V_{v,s} + \gamma_V e^V_{v,s} \right) + \frac{1}{N_v} \sum_{i=1}^{N_v} \left(\Delta_\tau r^c_{i,v,t} + \sum_{s=t-\tau+1}^{t} \xi_{i,v,s} \right) \quad (22)$$

We then use the following covariances for identification:

$$\mathrm{cov}(\Delta_\tau c_{i,v,t}, \Delta_\tau c_{i,v,t}) = \tau\delta_I^2 \mathrm{var}(u^I) + \tau\delta_V^2 \mathrm{var}(u^V) + \tau\gamma_I^2 \mathrm{var}(e^I) + \tau\gamma_V^2 \mathrm{var}(e^V) + 2\mathrm{var}(r^c) + \tau\mathrm{var}(\xi) \quad (23)$$

$$\mathrm{cov}(\Delta_\tau c_{i,v,t}, \Delta_\tau c_{i,v,t+\tau}) = -\mathrm{var}(r^c) \quad (24)$$

$$\mathrm{cov}(\Delta_\tau y_{i,v,t}, \Delta_\tau c_{i,v,t}) = \tau\delta_I \mathrm{var}(u^I) + \tau\delta_V \mathrm{var}(u^V) + \gamma_I \mathrm{var}(e^I) + \gamma_V \mathrm{var}(e^V) \quad (25)$$

$$\mathrm{cov}(\Delta_\tau y_{i,v,t+\tau}, \Delta_\tau c_{i,v,t}) = -\gamma_I \mathrm{var}(e^I) - \gamma_V \mathrm{var}(e^V) \quad (26)$$

$$\mathrm{cov}(\Delta_\tau \overline{c}_{v,t}, \Delta_\tau \overline{c}_{v,t}) = \tau\delta_V^2 \mathrm{var}(u^V) + \tau\gamma_V^2 \mathrm{var}(e^V) + \frac{1}{N_v} \left(2\mathrm{var}(r^c) + \tau\mathrm{var}(\xi) \right) \quad (27)$$

$$\mathrm{cov}(\Delta_\tau \overline{c}_{v,t}, \Delta_\tau \overline{c}_{v,t+\tau}) = -\frac{1}{N_v} \mathrm{var}(r^c) \quad (28)$$

$$\mathrm{cov}(\Delta_\tau \overline{y}_{v,t}, \Delta_\tau \overline{c}_{v,t}) = \tau\delta_V \mathrm{var}(u^V) + \gamma_V \mathrm{var}(e^V_t) \quad (29)$$

$$\mathrm{cov}(\Delta_\tau \overline{y}_{v,t+\tau}, \Delta_\tau \overline{c}_{v,t}) = -\gamma_V \mathrm{var}(e^V) \quad (30)$$

Equation (24) or (28) identify $\mathrm{var}(r^c)$. Since we have already identified income variances, (30) identifies γ_V and then it follows that (26) identifies γ_I and (29) identifies δ_V. Then (25) identifies δ_I. Finally, (23) or (27) identifies $\mathrm{var}(\xi)$.

Appendix C Sampling Bias of Transmission Parameters

In estimating the partial insurance model in Section 3, we only observe a sample of the households in the village. In this appendix, we investigate the extent to which this sampling may bias the estimation of transmission parameters. Specifically, we consider a simple model with only permanent shocks (dropping subscripts for readability): $\Delta y = u$, where a component $u_{V'}$ can be an actual village-aggregate shock (e.g., rainfall) and another component $u_{I'}$ is IID to each household. Let N be the total number of households in the village and n be the number of sampled households in the village ($n < N$).

We first define the true u_V and u_I from:

$$\Delta y = u = u_{V'} + u_{I'} \tag{31}$$

$$\Delta \overline{y} = \frac{1}{N}\sum_{i=1}^{N} u = \frac{1}{N}\sum_{i=1}^{N}(u_{V'} + u_{I'}) = u_{V'} + \frac{1}{N}\sum_{i=1}^{N}(u_{I'}) \equiv u_V \tag{32}$$

so the true village-aggregate shock u_V is the average of all shocks to households in the village and the true idiosyncratic shock u_I is the residual:

$$u_I \equiv u - u_V = u - u_{V'} - \frac{1}{N}\sum_{i=1}^{N}(u_{I'}) = u_{I'} - \frac{1}{N}\sum_{i=1}^{N}(u_{I'}) \tag{33}$$

Note that the last term in this equation ($\sum_{i=1}^{N}(u_{I'})$) washes out as $N \to \infty$ but the middle term ($u_{V'}$) does not.

The theory underlying our model dictates that the consumption equations are then:

$$\Delta c = \delta_V u_V + \delta_I u_I \tag{34}$$

$$\Delta \overline{c} = \delta_V u_V \tag{35}$$

and the variances of these equations are:

$$var(\Delta y) = var(u_{V'}) + var(u_{I'}) \tag{36}$$

$$var(\Delta \overline{y}) = var(u_V) = var(u_{V'}) + \frac{1}{N} var(u_{I'}) \tag{37}$$

$$var(\Delta y) - var(\Delta \overline{y}) = var(u_I) = \frac{N-1}{N} var(u_{I'}) \tag{38}$$

$$var(\Delta c) = \delta_V^2 var(u_V) + \delta_I^2 var(u_I) \tag{39}$$

$$var(\Delta \overline{c}) = \delta_V^2 var(u_V) \tag{40}$$

so the insurance parameters are identified from:

$$\delta_V^2 = \frac{var(\Delta \overline{c})}{var(\Delta \overline{y})} \tag{41}$$

$$\delta_I^2 = \frac{var(\Delta c) - var(\Delta \overline{c})}{var(\Delta y) - var(\Delta \overline{y})} \tag{42}$$

Now we work through what measured values we would get if we sampled only n households in a village. The income and consumption equations are now:

$$\Delta y^m = u_{V'} + u_{I'} \tag{43}$$

$$\Delta \overline{y}^m = \frac{1}{n} \sum_{i=1}^{n} u = \frac{1}{n} \sum_{i=1}^{n} (u_{V'} + u_{I'}) = u_{V'} + \frac{1}{n} \sum_{i=1}^{n} u_{I'} \tag{44}$$

$$\Delta c^m = \delta_V u_V + \delta_I u_I \tag{45}$$

$$= \delta_V \left(u_{V'} + \frac{1}{N} \sum_{i=1}^{N} u_{I'} \right) + \delta_I \left(u_{I'} - \frac{1}{N} \sum_{i=1}^{N} (u_{I'}) \right) \tag{46}$$

$$\Delta \overline{c}^m = \frac{1}{n} \sum_{i=1}^{n} (\delta_V u_V + \delta_I u_I) \tag{47}$$

$$= \delta_V \left(u_{V'} + \frac{1}{N} \sum_{i=1}^{N} u_{I'} \right) + \delta_I \left(\frac{1}{n} \sum_{i=1}^{n} u_{I'} - \frac{1}{N} \sum_{i=1}^{N} u_{I'} \right) \tag{48}$$

and the corresponding variances are:

$$var(\Delta y)^m = var(u_{V'}) + var(u_{I'}) \tag{49}$$

$$var(\Delta \overline{y})^m = var(u_{V'}) + \frac{1}{n} var(u_{I'}) \tag{50}$$

$$var(\Delta c)^m = \delta_V^2 \left(var(u_{V'}) + \frac{1}{N} var(u_{I'}) \right) + \delta_I^2 \left(\frac{N-1}{N} var(u_{I'}) \right) \tag{51}$$

$$var(\Delta \overline{c})^m = \delta_V^2 \left(var(u_{V'}) + \frac{1}{N} var(u_{I'}) \right) + \delta_I^2 \left(\frac{N-n}{nN} var(u_{I'}) \right) \tag{52}$$

Using the same identification arguments to identify the transmission parameters gives:

$$\delta_V^{2m} = \frac{var(\Delta \overline{c})^m}{var(\Delta \overline{y})^m} \tag{53}$$

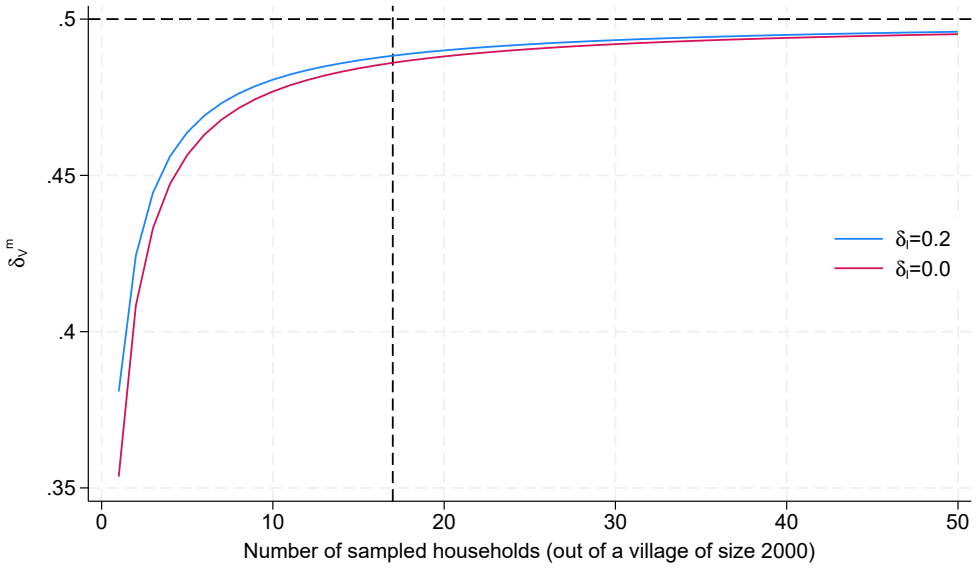
$$= \frac{\delta_V^2 \left(var(u_{V'}) + \frac{1}{N} var(u_{I'}) \right) + \delta_I^2 \left(\frac{N-n}{nN} var(u_{I'}) \right)}{var(u_{V'}) + \frac{1}{n} var(u_{I'})} \tag{54}$$

$$\delta_I^{2m} = \frac{var(\Delta c)^m - var(\Delta \overline{c})^m}{var(\Delta y)^m - var(\Delta \overline{y})^m} \tag{55}$$

$$= \frac{\delta_I^2 var(u_{I'}) \frac{n-1}{n}}{var(u_{I'}) \frac{n-1}{n}} = \delta_I^2 \tag{56}$$

Thus, there is bias in the transmission of village level shocks, but not idiosyncratic shocks. To see the magnitude of this bias, Appendix Figure 1 shows the bias for δ_V when the true $\delta_V = 0.5$ for a village of size $N = 2000$ and various sample sizes n on the x-axis and when $\delta_I = 0.2$ (blue line) and $\delta_I = 0.0$ (pink line), and the variance of the idiosyncratic and village-aggregate shocks are equal to 0.03. The bias when 17 households are sampled (the average sample size per village) is less than 0.015 (or less than 3% of a transmission parameter of 0.5), so we conclude that this bias is not concerning for the main takeaway of the paper.

Appendix Figure 1: Bias from Sampling



Note: Figure shows the bias for δ_V when the true $\delta_V = 0.5$ for a village of size $N = 2000$ and various sample sizes n on the x-axis and when $\delta_I = 0.2$ (blue line) and $\delta_I = 0.0$ (pink line), and the variance of the idiosyncratic and village-aggregate shocks are equal to 0.03.

Appendix D Derivation of Welfare Formula

In this appendix we derive the consumption equivalent formula used to compute the welfare declines reported in Table 6. Much of this derivation follows from Santaeulàlia-Llopis and Zheng (2018), though we derive a static formula for simplicity. We assume a CRRA utility function with risk aversion coefficient η and decompose consumption C_t into a baseline consumption level $\bar{c}$ and consumption risk c_t such that expected consumption is:

$$\begin{aligned}
E_t u(C_t) &= Eu(\bar{c} \cdot c_t) \\
&= E_t \frac{\bar{c}^{1-\eta}}{1-\eta}(c_t)^{1-\eta} \\
&= \frac{\bar{c}^{1-\eta}}{1-\eta} E_t \exp[(1-\eta)\ln(c_t)] \\
&= \frac{\bar{c}^{1-\eta}}{1-\eta} E_t \exp[(1-\eta)(\Delta \ln(c_t) + \ln(c_{t-1}))] \\
&= \frac{\bar{c}^{1-\eta}}{1-\eta} c_{t-1}^{1-\eta} E_t \exp[(1-\eta)\Delta \ln(c_t)] \\
&= \frac{\bar{c}^{1-\eta}}{1-\eta} c_{t-1}^{1-\eta} E_t \exp[(1-\eta)(\delta_I u^I_{i,v,t} + \delta_V u^V_{v,t} + \gamma_I e^I_{i,v,t} + \gamma_V e^V_{v,t} + \Delta r^c_{i,v,t} + \xi_{i,v,t})] \\
&= \frac{\bar{c}^{1-\eta}}{1-\eta} c_{t-1}^{1-\eta} \exp\left[\frac{1}{2}(1-\eta)^2(\delta_I^2 \sigma^2_{u^I} + \delta_V^2 \sigma^2_{u^V} + \gamma_I^2 \sigma^2_{e^I} + \gamma_V^2 \sigma^2_{e^V} + \sigma^2_{r^c} + \sigma^2_\xi)\right]
\end{aligned}$$

where the second to last line comes from equation (12) and the final line follows from the assumption that the terms inside the exp() function are independent and normally distributed with mean zero and variance $(1-\eta)^2(\delta_I^2 \sigma^2_{u^I} + \delta_V^2 \sigma^2_{u^V} + \gamma_I^2 \sigma^2_{e^I} + \gamma_V^2 \sigma^2_{e^V} + \sigma^2_{r^c} + \sigma^2_\xi)$.[40]

We define the consumption equivalent of moving from an environment A to environment B, where an environment is defined as a combination of income risk and consumption insurance parameters $(\sigma_{u^I,i}, \sigma_{u^V,i}, \sigma_{e^I,i}, \sigma_{e^V,i}, \delta_{I,i}, \delta_{V,i}, \gamma_{I,i}, \gamma_{V,i})$ for environment $i = A, B$, as the proportional change $(1+\omega)$ in baseline consumption to be indifferent between the two environments:

$$\begin{aligned}
&\frac{((1+\omega)\bar{c})^{1-\eta}}{1-\eta} E_t(c_{A,t})^{1-\eta} = \frac{(\bar{c})^{1-\eta}}{1-\eta} E_t(c_{B,t})^{1-\eta} \\
\Leftrightarrow \quad &(1+\omega)^{1-\eta} = \frac{\exp\left(\frac{1}{2}(1-\eta)^2(\delta^2_{I,B}\sigma^2_{u^I,B} + \delta^2_{V,B}\sigma^2_{u^V,B} + \gamma^2_{I,B}\sigma^2_{e^I,B} + \gamma^2_{V,B}\sigma^2_{e^V,B} + \sigma^2_{r^c} + \sigma^2_\xi)\right)}{\exp\left(\frac{1}{2}(1-\eta)^2(\delta^2_{I,A}\sigma^2_{u^I,A} + \delta^2_{V,A}\sigma^2_{u^V,A} + \gamma^2_{I,A}\sigma^2_{e^I,A} + \gamma^2_{V,A}\sigma^2_{e^V,A} + \sigma^2_{r^c} + \sigma^2_\xi)\right)}
\end{aligned}$$

[40] The normality assumption is only necessary for this welfare exercise; it is otherwise not imposed in our other analyses.

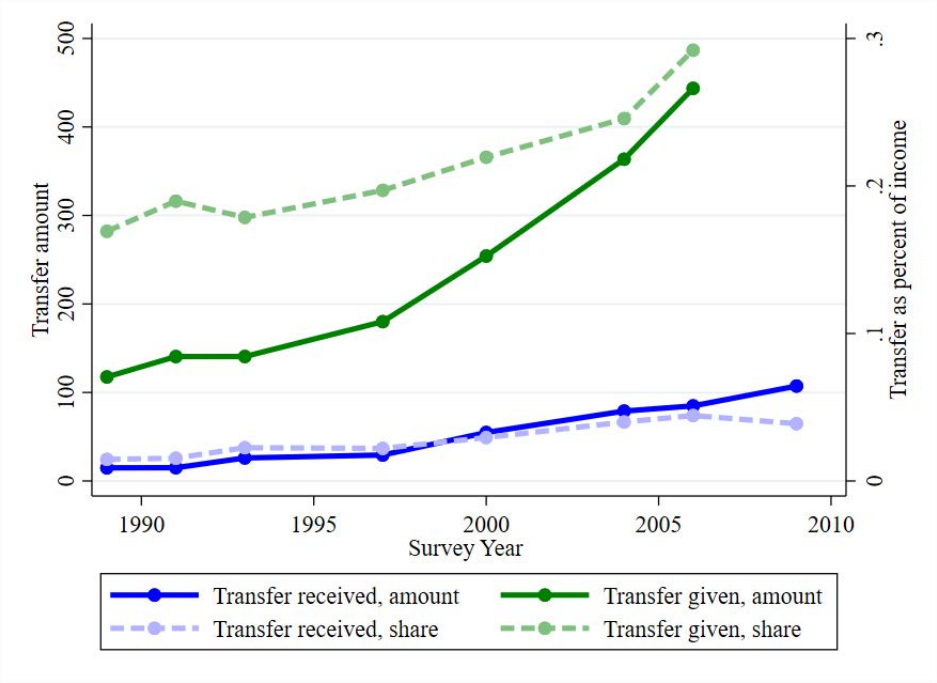
Appendix E Transfers and Taxes

In this section, we provide a more thorough description of private transfers, public transfers, and taxes.

Private Transfers. In our analysis, we focus on a measure of household income that excludes private transfers, as private transfers can potentially be used as an instrument of insurance. The CHNS Household Surveys ask, at the household-level, about transfers received from family and friends (in cash and in kind) from 1989 to 2009, and transfers given out to family and friends in cash and in kind as well as expenditures on wedding, dowry or funeral from 1989 to 2006. Appendix Figure 2 plots the absolute level as well as the share of income of private transfers received and given. On average, private transfers received account for only a small fraction of total income (between 3% and 5%). Private transfers given account for a higher fraction of total income, on the order of 20% to 30%.

We then regress net transfers, as measured by the difference between private transfers received and given out, on household income (both in levels instead of logs since net transfers can be negative). Appendix Table 4 shows that a 1 yuan increase in household income corresponds to a decrease in transfers received of 0.02 yuan, which is consistent with the idea that private transfers can be used as a source of informal insurance. More generally, as insurance provided by local public institutions (such as collective TVEs) declined, informal risk sharing increased in response – though not enough to offset the decline.

Appendix Figure 2: Mean Private Transfers Received and Given, CHNS Rural Sample 1989-2009



Appendix Table 4: Net Private Transfers Received and Household Income (Excluding Private Transfers), Townsend-Style Tests

	Net private transfers received	
	(1)	(2)
Household income	-0.020***	
	(0.007)	
Household income x pre-1998		-0.012*
		(0.007)
Household income x post-1998		-0.022**
		(0.009)
Observations	11585	11585
R-squared	0.408	0.408

Notes: Regressions use household level income and net private transfers received for 1989-2006. Controls include village-year fixed effects and household fixed effects, and standard errors (in parentheses) are clustered by village. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Public Transfers. Our measure of income includes public transfers, which are surveyed in great detail in the CHNS Household Surveys. Specifically, our measure of public transfers includes the imputed value of food coupons (available from 1989 to 1993 only), subsidies from the work unit such as subsidies for meat or groceries, health, bathing or haircuts, books or newspapers, housing,

and others (available from 1989 to 1997 only), subsidies from the government such as the one child subsidy, the gas and fuel subsidy, the coal subsidy, the electricity subsidy, and the child care subsidy and pension (Appendix A.3 of Santaeulàlia-Llopis and Zheng (2018) has detailed description of the imputation procedure, variable construction, and cross validation). Appendix Table 5 reports the share of total income accounted for by public transfers for our rural sample and the urban sample of the CHNS separately, and shows that public transfers are a much more important source of income for urban households than for our rural households. In addition, the decline in the importance of the public transfers is also more evident in the urban sample than the rural sample. For the rural sample, which is the focus of our paper, public transfers only account for about 6.5% of total income across years, without a clear time trend.

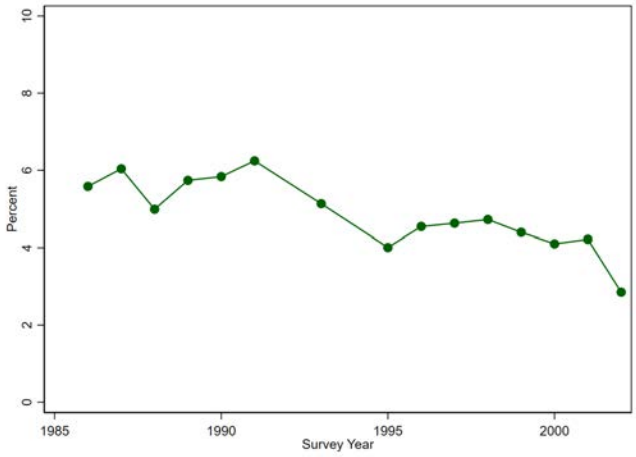
Appendix Table 5: Public Transfers to Households, CHNS 1989-2009

	Urban	Rural
1989	30.29	8.21
1991	33.39	8.49
1993	26.93	6.15
1997	17.39	3.33
2000	23.03	4.74
2004	29.10	7.22
2006	29.51	7.14
2009	23.83	7.03

Taxes. Our measure of income is pre-tax because the CHNS does not ask about taxes paid. To get a sense of the amount of taxes paid by households similar to those in our sample, we turn to the Rural Household Survey (RHS), which surveys taxes and fees paid by rural households in six provinces over the 1986-2002 period. The RHS is the official survey administrated by the China Bureau of Statistics that collects detailed income and expenditure information from a nationally representative sample since 1955. This data however has only been made available to a limited number of academics for a few survey years and a few provinces at a time. We obtained a subsample of RHS from the Chinese University of Hong Kong's Universities Service Centre for China Studies, which includes six provinces (Liaoning, Shandong, Hubei, Guangdong, Yunnan, and Gansu) between 1986 and 2002 (skipping 1992 and 1994). In Appendix Figure 3, we report mean household average tax rates

by year, computed as the ratio of total taxes and fees paid to total household income from the RHS sample. Overall the tax burden is relatively low for the rural households, at around 4.87% of total household income on average. There is a slight downward trend from around 6% to around 3% from 1986 to 2002. Because of the relatively small magnitude of taxes and fees as compared to the total income in rural China over our sample period, we do not think we miss much by focusing on pre-tax income in the CHNS.

Appendix Figure 3: Tax and Fees as a Percent of Total Household Income, RHS



Note: Data from the Rural Household Survey, 1986-2002, from a sample of rural households in six of the provinces used in our analysis. Mean household average tax rates computed as the ratio of total taxes and fees paid to total household income.

Appendix F Additional Tables

F.1 Income Parameters with Various Measurement Error Assumptions

Here we report the estimated income process parameters under various assumptions on income measurement errors in Appendix Table 6. In the paper, we assume an income measurement error of 0.05 and here we consider values of 0.01 and 0.10. Estimates of permanent shocks are not affected by the alternative measurement error assumptions, while estimates of transitory shocks are only slightly affected in intuitive ways.

Appendix Table 6: Income Parameter Estimates, Various Measurement Error Assumptions

	Permanent shocks		Transitory shocks	
	Idiosyncratic	Village-aggregate	Idiosyncratic	Village-aggregate
Panel A: Measurement error = 0.01				
1989-1997 period	0.027	0.026	0.357	0.034
	(0.012)	(0.005)	(0.027)	(0.007)
1998-2009 period	0.034	0.024	0.425	0.047
	(0.011)	(0.024)	(0.028)	(0.008)
Panel B: Measurement error = 0.05				
1989-1997 period	0.027	0.026	0.320	0.031
	(0.012)	(0.005)	(0.027)	(0.007)
1998-2009 period	0.034	0.024	0.389	0.043
	(0.011)	(0.005)	(0.028)	(0.008)
Panel C: Measurement error = 0.10				
1989-1997 period	0.027	0.026	0.274	0.027
	(0.012)	(0.005)	(0.027)	(0.007)
1998-2009 period	0.034	0.023	0.344	0.039
	(0.011)	(0.004)	(0.028)	(0.008)

Note: Panels correspond to different assumptions of the variance of income measurement error. Standard errors in parentheses are based on 50 block bootstrap replications, clustered by village.

F.2 Tests of Full and Partial Consumption Insurance Using Total Consumption

In this section, we re-run our baseline estimations using total consumption instead of food consumption. This measure includes, in addition to food, a limited number of non-food consumption goods such as utilities, health related expenditures, electronics, and kitchenwares. Since this measure is still predominantly (over 90%) food, the results using this consumption measure are very similar to our baseline results using household food.

Appendix Table 7 and Appendix Table 8 report the full consumption insurance tests in levels and first differences. In Appendix Table 9, we repeat our baseline estimation of the partial insurance

using total consumption instead of food consumption as the consumption measure. The results are very similar to what we report in the main paper using food consumption measure.

Appendix Table 7: Tests of Full Consumption Insurance within Villages, Total Consumption

	Log household cons.		Change in log household cons.	
	(1)	(2)	(3)	(4)
Log household income	0.075***			
	(0.009)			
Log household income x pre-1998		0.043***		
		(0.010)		
Log household income x post-1998		0.100***		
		(0.012)		
Change in log household income			0.053***	
			(0.010)	
Change in log household income x pre-1998				0.023**
				(0.011)
Change in log household income x post-1998				0.072***
				(0.013)
P-value of difference in coefficients, pre-post		0.000		0.002
Observations	12881	12881	9072	9072
R-squared	0.631	0.632	0.292	0.293

Note: Regressions in columns (1) and (2) correspond to the levels specification in equation (6), use household level income and total consumption, control for village-year fixed effects and household fixed effects, and standard errors (in parentheses) are clustered by village. Regressions in columns (3) and (4) correspond to the first-differences specification in equation (7), use changes in household income and total consumption, control for village-year fixed effects, and standard errors (in parentheses) are clustered by village. P-value row reports the p-value of differences between the coefficient on the income variable interacted with pre-1998 and the coefficient on the income variable interacted with post-1998. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 8: Tests of Full Consumption Insurance across Villages, Total Consumption

	Average log household cons.		Change in average log household cons.	
	(1)	(2)	(3)	(4)
Average log household income	0.103***			
	(0.023)			
Average log household income x pre-1998		0.053		
		(0.040)		
Average log household income x post-1998		0.137***		
		(0.036)		
Change in average log household income			0.066*	
			(0.034)	
Change in average log household income x pre-1998				0.060*
				(0.032)
Change in average log household income x post-1998				0.069
				(0.052)
P-value of difference in coefficients, pre-post		0.158		0.899
Observations	1084	1084	916	916
R-squared	0.673	0.675	0.288	0.288

Note: Regressions in columns (1) and (2) correspond to the levels specification in equation (8), use household level income and total consumption averaged at the village level, control for village and province-year fixed effects, and standard errors (in parentheses) are clustered by province. Regressions in columns (3) and (4) correspond to the first-differences specification in equation (9), use changes over time in average household level income and total consumption aggregated to the village level, control for province-year fixed effects, and standard errors (in parentheses) are clustered by province. P-value row reports the p-value of differences between the coefficient on the income variable interacted with pre-1998 and the coefficient on the income variable interacted with post-1998. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 9: Estimates of Partial Insurance Model, Total Consumption

	Permanent shocks		Transitory shocks	
	Idiosyncratic	Village-aggregate	Idiosyncratic	Village-aggregate
Panel A: Parameter estimates				
1989-1997 period				
Income variance	0.027	0.026	0.320	0.031
	(0.012)	(0.005)	(0.027)	(0.007)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.042	0.122	0.000	0.000
	(0.035)	(0.162)	(0.007)	(0.149)
1998-2009 period				
Income variance	0.034	0.024	0.389	0.043
	(0.011)	(0.005)	(0.028)	(0.008)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.120	0.599	0.044	0.000
	(0.104)	(0.252)	(0.020)	(0.262)
Panel B: χ^2 test of differences over time				
Income variance	0.35	0.16	5.69	1.52
	(0.55)	(0.69)	(0.02)	(0.22)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.52	2.41	5.17	0.00
	(0.47)	(0.00)	(0.02)	(1.00)
Joint test, income		13.93 (0.01)		
Joint test, transmission		10.06 (0.04)		

Note: Also estimated are total consumption heterogeneity and total consumption measurement error, both for the pre-period and post-period (not shown). Income measurement error is set to 0.05. Panel A: Standard errors in parentheses are based on 50 block bootstrap replications, clustered by village. Panel B: p-values of χ^2 test in parentheses. The joint tests are of all 4 pairwise comparisons for the respective parameter grouping.

F.3 Tests of Full and Partial Consumption Insurance Dropping Villages that Sample Fewer than 14 Households

In this section, we drop villages for which we observe fewer than 14 households from the sample and rerun the full and partial consumption insurance tests with both food consumption and total consumption measures. We verify the results are quite similar to those in the main paper.

For the full insurance tests, Appendix Table 10 and Appendix Table 11 report the results with food consumption measure for level and first difference specifications. Appendix Table 12 and Appendix Table 13 report the results with total consumption measure for level and first difference specifications. For the partial insurance models, Appendix Table 14 reports the results with food consumption and Appendix Table 15 reports the results with total consumption.

Appendix Table 10: Tests of Full Consumption Insurance within Villages, 14+ Households, Food Consumption

	Log household food		Change in log household food	
	(1)	(2)	(3)	(4)
Log household income	0.073***			
	(0.010)			
Log household income x pre-1998		0.038***		
		(0.011)		
Log household income x post-1998		0.101***		
		(0.014)		
Change in log household income			0.048***	
			(0.011)	
Change in log household income x pre-1998				0.014
				(0.012)
Change in log household income x post-1998				0.070***
				(0.014)
P-value of difference in coefficients, pre-post		0.000		0.001
Observations	12065	12065	8381	8381
R-squared	0.643	0.644	0.308	0.309

Note: Sample restricted to villages that sample at least 14 households. Regressions in columns (1) and (2) correspond to the levels specification in equation (6), use household level income and food consumption, control for village-year fixed effects and household fixed effects, and standard errors (in parentheses) are clustered by village. Regressions in columns (3) and (4) correspond to the first-differences specification in equation (7), use changes in household income and food consumption, control for village-year fixed effects, and standard errors (in parentheses) are clustered by village. P-value row reports the p-value of differences between the coefficient on the income variable interacted with pre-1998 and the coefficient on the income variable interacted with post-1998. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 11: Tests of Full Consumption Insurance across Villages, 14+ Households, Food Consumption

	Average log household food		Change in average log household food	
	(1)	(2)	(3)	(4)
Average log household income	0.083***			
	(0.024)			
Average log household income x pre-1998		0.009		
		(0.041)		
Average log household income x post-1998		0.140**		
		(0.042)		
Change in average log household income			0.072*	
			(0.032)	
Change in average log household income x pre-1998				0.022
				(0.037)
Change in average log household income x post-1998				0.100
				(0.054)
P-value of difference in coefficients, pre-post		0.074		0.324
Observations	961	961	768	768
R-squared	0.666	0.671	0.296	0.297

Note: Sample restricted to villages that sample at least 14 households. Regressions in columns (1) and (2) correspond to the levels specification in equation (8), use household level income and food consumption averaged at the village level, control for village and province-year fixed effects, and standard errors (in parentheses) are clustered by province. Regressions in columns (3) and (4) correspond to the first-differences specification in equation (9), use changes over time in average household level income and food consumption aggregated to the village level, control for province-year fixed effects, and standard errors (in parentheses) are clustered by province. P-value row reports the p-value of differences between the coefficient on the income variable interacted with pre-1998 and the coefficient on the income variable interacted with post-1998. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 12: Tests of Full Consumption Insurance within Villages, 14+ Households, Total Consumption

	Log household cons.		Change in log household cons.	
	(1)	(2)	(3)	(4)
Log household income	0.073***			
	(0.010)			
Log household income x pre-1998		0.043***		
		(0.011)		
Log household income x post-1998		0.097***		
		(0.013)		
Change in log household income			0.050***	
			(0.010)	
Change in log household income x pre-1998				0.021*
				(0.012)
Change in log household income x post-1998				0.068***
				(0.014)
P-value of difference in coefficients, pre-post		0.000		0.007
Observations	11804	11804	8078	8078
R-squared	0.632	0.632	0.290	0.290

Note: Sample restricted to villages that sample at least 14 households. Regressions in columns (1) and (2) correspond to the levels specification in equation (6), use household level income and total consumption, control for village-year fixed effects and household fixed effects, and standard errors (in parentheses) are clustered by village. Regressions in columns (3) and (4) correspond to the first-differences specification in equation (7), use changes in household income and total consumption, control for village-year fixed effects, and standard errors (in parentheses) are clustered by village. P-value row reports the p-value of differences between the coefficient on the income variable interacted with pre-1998 and the coefficient on the income variable interacted with post-1998. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 13: Tests of Full Consumption Insurance across Villages, 14+ Households, Total Consumption

	Average log household cons.		Change in average log household cons.	
	(1)	(2)	(3)	(4)
Average log household income	0.105***			
	(0.024)			
Average log household income x pre-1998		0.041		
		(0.041)		
Average log household income x post-1998		0.154***		
		(0.041)		
Change in average log household income			0.078**	
			(0.028)	
Change in average log household income x pre-1998				0.049
				(0.034)
Change in average log household income x post-1998				0.095
				(0.054)
P-value of difference in coefficients, pre-post		0.102		0.574
Observations	961	961	768	768
R-squared	0.692	0.696	0.321	0.321

Note: Sample restricted to villages that sample at least 14 households. Regressions in columns (1) and (2) correspond to the levels specification in equation (8), use household level income and total consumption averaged at the village level, control for village and province-year fixed effects, and standard errors (in parentheses) are clustered by province. Regressions in columns (3) and (4) correspond to the first-differences specification in equation (9), use changes over time in average household level income and total consumption aggregated to the village level, control for province-year fixed effects, and standard errors (in parentheses) are clustered by province. P-value row reports the p-value of differences between the coefficient on the income variable interacted with pre-1998 and the coefficient on the income variable interacted with post-1998. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 14: Estimates of Partial Insurance Model, Food Consumption

	Permanent shocks		Transitory shocks	
	Idiosyncratic	Village-aggregate	Idiosyncratic	Village-aggregate
Panel A: Parameter estimates				
1989-1997 period				
Income variance	0.032	0.025	0.313	0.030
	(0.012)	(0.006)	(0.028)	(0.009)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.034	0.008	0.000	0.000
	(0.034)	(0.153)	(0.003)	(0.218)
1998-2009 period				
Income variance	0.032	0.023	0.398	0.041
	(0.012)	(0.004)	(0.023)	(0.008)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.112	0.709	0.035	0.000
	(0.185)	(0.279)	(0.021)	(0.329)
Panel B: χ^2 test of differences over time				
Income variance	0.00	0.08	6.69	0.72
	(0.98)	(0.78)	(0.01)	(0.40)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.18	5.01	2.97	0.00
	(0.67)	(0.03)	(0.09)	(1.00)
Joint test, income		9.98 (0.04)		
Joint test, transmission		12.53 (0.01)		

Note: Sample restricted to villages that sample at least 14 households. Also estimated are food consumption heterogeneity and food consumption measurement error, both for the pre-period and post-period (not shown). Income measurement error is set to 0.05. Panel A: Standard errors in parentheses are based on 50 block bootstrap replications, clustered by village. Panel B: p-values of χ^2 test in parentheses. The joint tests are of all 4 pairwise comparisons for the respective parameter grouping.

Appendix Table 15: Estimates of Partial Insurance Model, Total Consumption

	Permanent shocks		Transitory shocks	
	Idiosyncratic	Village-aggregate	Idiosyncratic	Village-aggregate
Panel A: Parameter estimates				
1989-1997 period				
Income variance	0.032	0.025	0.313	0.030
	(0.012)	(0.006)	(0.028)	(0.009)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.026	0.152	0.000	0.000
	(0.038)	(0.195)	(0.007)	(0.106)
1998-2009 period				
Income variance	0.032	0.023	0.398	0.041
	(0.012)	(0.004)	(0.023)	(0.008)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.122	0.673	0.038	0.000
	(0.154)	(0.245)	(0.022)	(0.292)
Panel B: χ^2 test of differences over time				
Income variance	0.00	0.08	6.69	0.72
	(0.98)	(0.78)	(0.01)	(0.40)
Transmission $(\delta_I, \delta_V, \gamma_I, \gamma_V)$	0.38	2.77	2.72	0.00
	(0.54)	(0.10)	(0.10)	(1.00)
Joint test, income		9.98 (0.04)		
Joint test, transmission		8.76 (0.07)		

Note: Sample restricted to villages that sample at least 14 households. Also estimated are total consumption heterogeneity and total consumption measurement error, both for the pre-period and post-period (not shown). Income measurement error is set to 0.05. Panel A: Standard errors in parentheses are based on 50 block bootstrap replications, clustered by village. Panel B: p-values of χ^2 test in parentheses. The joint tests are of all 4 pairwise comparisons for the respective parameter grouping.

F.4 Village-Level Consumption Smoothing, Interacted with Provincial Characteristics

We regress village average household food consumption on village average household income, interacted with village-level characteristics aggregated to the province level, controlling for village fixed effects and province-year fixed effects, separately for pre- and post-1998 periods. The results are found in Appendix Table 16. It is clear that the village average consumption covaries much more with village average income in the post-1998 period relative to the pre-1998 period. However, village characteristics such as the share in agriculture, the share of migrants, and the presence of TVEs do not explain the difference in the degree of insurance between the two periods. To understand the increase in the pass through coefficients in the post-1998 period of village aggregate risk, we must look beyond village characteristics.

Appendix Table 16: Consumption Smoothing, Interacted with Provincial Characteristics, Village-Level

	Average log household food consumption				
	(1)	(2)	(3)	(4)	(5)
Average log household income x pre-1998	0.025	0.161	0.145	-0.016	0.386
	(0.031)	(0.122)	(0.095)	(0.101)	(0.250)
x Province avg agriculture		-0.002			-0.004
		(0.002)			(0.002)
x Province avg migration			-0.006		-0.007
			(0.005)		(0.005)
x Province avg collective enterprises				0.001	-0.000
				(0.002)	(0.002)
Average log household income x post-1998	0.140***	0.255**	0.141	0.070	0.182
	(0.031)	(0.099)	(0.130)	(0.056)	(0.198)
x Province avg agriculture		-0.002			-0.003
		(0.002)			(0.002)
x Province avg migration			-0.000		0.000
			(0.004)		(0.005)
x Province avg collective enterprises				0.003*	0.004*
				(0.002)	(0.002)
Mean interacted variable, pre-1998		59.35	19.85	56.39	
SD interacted variable, pre-1998		12.77	5.691	18.09	
Mean interacted variable, post-1998		50.69	29.87	21.00	
SD interacted variable, post-1998		13.95	7.442	15.37	
F-stat, pre-1998 interactions					1.272
F-stat, post-1998 interactions					1.305
Observations	1084	1084	1084	1084	1084
R-squared	0.654	0.655	0.655	0.656	0.658

Note: Each column is a separate regression of village-average log household food consumption on village-average log household income interacted with pre-1998 and post-1998, and in columns (2)-(5) also interacted with provincial averages of village economic conditions. Means and standard deviations of the interacted variables in columns (2)-(4), and F-stats of the interaction terms by pre/post in column (5), are in the lower panel of the table. Standard errors in parentheses are clustered by village. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$