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Abstract

We consider risk sharing in rural China during 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 from agriculture to wage employment, 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 shocks.

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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, strong private 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). However, less is known about how informal insurance arrangements are affected in periods of rapid development and changes in the public and private institutions that transform close-knit communities. This paper aims to fill this gap, with the particular example of China.

We propose a framework to estimate the extent of risk sharing both within a small risk-sharing group and across these groups within a broader economy, and 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 analysis is based on the seminal (Townsend, 1994) complete market tests 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). Our empirical setting is rural villages in China during a period of rapid economic transformation. Building on Santaeulàlia-Llopis and Zheng (2018), who document that consumption insurance declined substantially in China from the late 1980s through the late 2000s, we use our new framework to further show how consumption insurance both within and across villages has declined and explore 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. From 1989 to 2009, rural China was in the midst of a transformation from a planned economy centered around agriculture to an industrial economy, first largely through public ownership and then swiftly transitioning to private 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 consumption insurance for households: 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 standard 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 diversified *across villages*. We reject full insurance against both types of risk, and 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 welfare (since, for example, transitory shocks are more easily insured through savings). In our second set of exercises, we use a partial insurance framework developed by Blundell, Pistaferri, and Preston (2008) to decompose income shocks into transitory and permanent components. We further expand the framework by decomposing both permanent and transitory income shocks into a component that is common within a village—which cannot be easily insured by the village—and a component that is purely idiosyncratic and can, therefore, be insured within the village. We conduct this exercise using the approach developed by Attanasio, Meghir, and Mommaerts (2015). 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,

[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.

and village-level and purely idiosyncratic—and how this insurance has changed over time.

We estimate this partial insurance model using method of moments 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 does not change much 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. We also find that all types of income shocks were well insured in the early years of our sample period, but that this insurance deteriorated 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 and around 80% of idiosyncratic transitory shocks were insured in the 2000s. Consumption equivalent calculations imply that the welfare cost of these changes 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 findings about degree of consumption insurance obtained with these two different approaches show 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 mechanisms behind both the decrease in consumption insurance from within the village and the decrease in consumption insurance from outside sources. We show that the deterioration of insurance was more pronounced in regions of the country where (a) the agriculture sector was weaker, (b) migration rates were higher, and (c) there were fewer publicly owned Township-and-Village Enterprises (TVEs). These attributes, which characterize the economic transformation of rural China in the 1990s and 2000s, all weaken insurance *within* the village, as villages have less ability to provide social insurance from TVE revenue and household migration can weaken inter-household bonds.[2]

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

[2]Morten (2019) shows that migration weakens the ability of a village network to insure its members in the Indian context, while Meghir, Mobarak, Mommaerts *et al.* (2021) show that migration can alternatively strengthen the ability of a network to insure its members, depending on the riskiness of migration.

balance sheets from 1993 to 2007. We find that county government tax revenue and spending increasingly co-vary with output over time, while transfer programs, which were set up for insurance and redistribution purposes, become less negatively correlated over time. These findings suggest 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 the contrast between within- and across-village insurance. In fact, 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.

More generally, our findings suggest that the growth experience of China offers valuable lessons to other transition economies. How much risk-sharing is achieved within a group is endogenous to the economic environment. The level of risk sharing that arises and is maintained in agrarian or collective economies may no longer be effective or sustainable when pro-growth market incentives are introduced. In this sense, our paper and findings relate to the body of work 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

[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.

[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.

changing economic landscape of rural China, including agricultural reforms, the rise and fall of Township and Village Enterprises, 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. 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 intergovernmental fiscal system. Section 7 concludes.

2 The Changing Economic Landscape of Villages in China

The economic landscape of rural villages in China has undergone dramatic changes over the past several decades. From 1989 to 2009, rural households in our sample experienced remarkable growth: adult-equivalent household income roughly tripled and consumption roughly doubled over the sample period (Figure 1(a)).[5] In this section, we provide an overview of the economic transformation that occurred in rural China from the beginning of the Reform and Opening Policy in 1978 until 2009, and discuss its implications for consumption insurance. This process of economic transformation can be broken down into two phases, (1) 1978 through the mid-1990s and (2) the mid-1990s through 2009. Prior to the reforms in 1978, the country was under a strict state planning system in which all production and consumption allocations were determined by the central government and implemented through multiple levels of sub-national governments.

Phase I: Agricultural Reforms, TVEs, and the Decentralization of Fiscal Power

The first phase of economic transformation (from 1978 to the mid-1990s) featured a set of reforms in the agricultural and rural industrial sectors that introduced market-based incentives to the centrally controlled economic planning system. In the agricultural sector, rural households became the residual claimant of their agricultural output following the introduction of the Household Responsibility System. This sparked an improvement in agricultural productivity which then led to a transition out of agriculture and into rural industrialization (Lin, 1992). Figure 1(b) shows this shift over the course of our sample period: in 1989, 90% of villages had farmland and 55% of the

[5]The data underlying this figure are discussed in more detail in Sections 4 and 6.2.

working age population worked on a farm, while by 2009, only 70% of villages had any farmland and 45% of the working age population worked in agriculture.

In the industrial sector, a new type of enterprise called Township and Village Enterprises (TVEs) mushroomed in the Chinese countryside. Unlike state-owned enterprises (SOEs), which were still fully integrated into the central planning system throughout the 1980s, TVEs were rural industrial firms controlled by the local township and village governments. Because of their independence from the central government, they provided an additional source of revenue to local governments to help finance the provision of local public goods, and were in a unique position to respond to market forces. TVEs expanded rapidly throughout the 1980s and early 1990s. The share of total industrial output contributed by rural TVEs increased from 9% in 1978 to 16% in 1985, and reached 27% by 1992, while the share contributed by SOEs fell to below 50% during the same period (Naughton, 1994).

These economic transformations were politically feasible due to a changing relationship between the central and sub-national governments.[6] Compared to the pre-reform planned economy, during which sub-national governments simply implemented the central government's plans, this phase entailed a major shift in power from the center to local governments. Local governments were newly allowed to make major personnel and investment decisions (the agricultural and industrial reforms were borne out of such decisions) and they retained substantial control over their budget. 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).

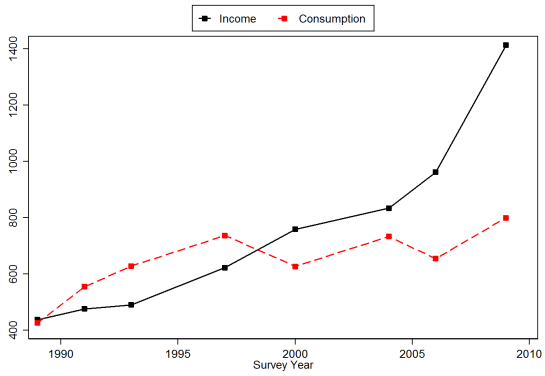
Phase II: Privatization and the Recentralization of Fiscal Power

The second phase (from the mid-1990s to the late 2000s) saw the recentralization of fiscal power and the decline of the TVEs. To improve its financial situation, the central government launched a wide-ranging tax reform in 1994. Notably, the reform required that value-added taxes (the major tax for the industrial sector) be shared 75%-25% between the central and local government.[7] This

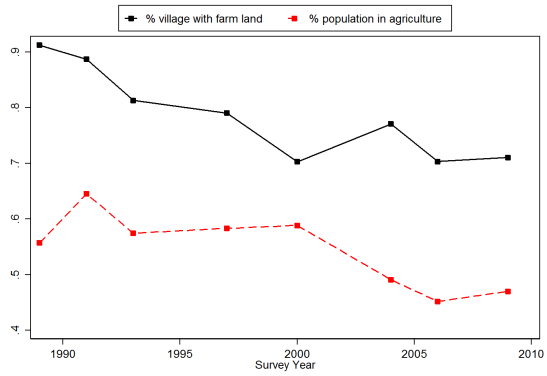
[6] China's unitary political system features a hierarchy with the central government at the top and four tiers of sub-national government: province, prefecture, county and township.

[7] In addition to VAT, business taxes (for services) were shared 3%-97% between the center and local. Other taxes were explicitly assigned to either the central or local government: for example, custom duties and excise taxes are collected by the central government, while property taxes and urban maintenance taxes are collected by localities.

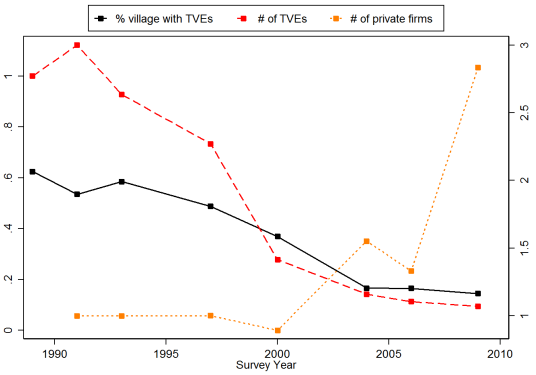
Figure 1: Economic Transformation in rural China, CHNS and EPS 1989-2009



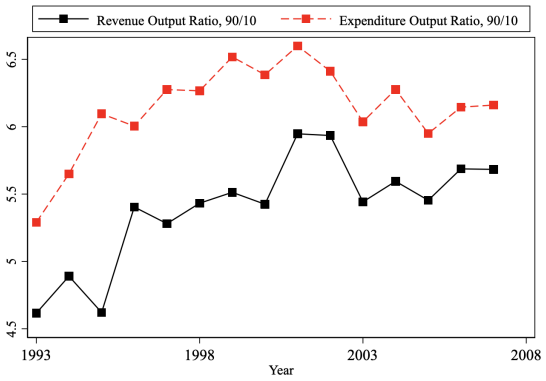
(a) Household income and consumption, CHNS



(b) Agricultural sector, CHNS



(c) Industrial sector, CHNS



(d) County fiscal resources, EPS

Note: Panel (a)-(c) are based on the CNHS sample and Panel (d) is based on the EPS county-level fiscal balance sheet sample. In Panel (a), the numbers are annual income and consumption, valued in 2009 USD. In Panel (c), the number of TVEs per village is normalized to 1 in 1989 and the number of private enterprises per village is normalized to 1 in 1991, the first wave in which this information is collected. Panel (d) shows, by year, the 90-10 ratios of the county-level fiscal revenue to output ratios and of the county-level local fiscal expenditure to output ratios.

change significantly reduced township and village governments' fiscal incentive to grow the TVEs (Kung and Lin, 2007). Additionally, the emergence of private enterprises from rural networks (Dai, Mookherjee, Munshi *et al.*, 2019) and large scale privatization of the SOEs during the 1990s grew into a private sector that nearly wiped out TVEs from the market. Figure 1(c) shows that the number of TVEs and the fraction of villages with TVEs in our sample declined rapidly beginning in the early- to mid-1990s, while the number of private enterprises surged. The demise of TVEs negatively impacted public good provision at the local level. Table 1 shows that 78% of villages with TVEs in our sample used TVE revenue to help fund public expenditures, and an average of

For details, see Shen, Jin, and Zou (2012).

21% of TVE revenue was spent on public goods such as infrastructure, education, pension and welfare assistance, and health insurance. With the decline of TVEs, this particular source of public finance dried out.

Table 1: Village TVE Funding of Various Public Expenditures, CHNS Villages, 1989-2009

	% of villages w/ TVEs contributing to	% of TVE revenue spent on
Any Spending	77.78	20.54
Housing Subsidy	4.43	7.01
Health Insurance	21.35	5.13
Education Subsidy	42.75	11.33
Irrigation Project	37.45	9.84
Infrastructure (Roads etc.)	52.59	12.11
Maintenance of Farm Machinery	36.57	12.30
Pension and Welfare Assistance	36.80	9.51
Grain Subsidy	6.77	5.66
Electricity Subsidy	11.94	9.09

Note: Data come from the Community Survey of the 1989-2009 CHNS. The sample includes all villages with at least one TVE, and are averaged over all waves, as there are no clear time trends in these variables.

As fiscal resources became recentralized and local governments' ownership of the rural industrial sector dwindled, fiscal responsibilities of local governments became increasingly difficult to fulfill. In recognition of this, the central government instituted an intergovernmental transfer system, which features a "general transfer" program that provides long-term periodic funds aimed at redistributing resources from fiscal-rich areas to fiscal-poor areas, as well as a "special transfer" program that provides ad hoc transfers to facilitate specific central policies. Existing research, however, shows that this transfer system falls short of filling the gap of fiscal needs in towns and villages and cannot offset the trend of growing fiscal inequality across different parts of China (see Shen, Jin, and Zou (2012) for a review).[8] Indeed, Figure 1(d) shows the growing inequality of total fiscal revenue-to-output ratios across counties, where the fiscal revenue includes transfers from the intergovernmental transfer system, together with the growing inequality of public expenditure-to-output ratios across counties, both measured by the 90/10 ratio.

In sum, it is indisputable that rural households in China on average experienced remarkable income growth. This growth came from diversifying their income portfolios from agricultural to

[8]For example, it was not until mid-2000s that the central government realized the urgency to intervene in rural social insurance provision. 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 only in 2009.

non-agricultural sources, and from productivity growth brought by increased market incentives and private ownership (Zhu, 2012). However, along with this growth came increased inequality and fewer potential sources of insurance. To quantify this potential breakdown of consumption insurance, we next describe a conceptual framework from which we derive our empirical tests of risk sharing.

3 A Framework for Quantifying Deviations from Perfect Risk Sharing and Their Drivers

This section provides a conceptual framework for risk sharing within and across groups and derives empirical tests of risk sharing that we then take to data in Section 5.

3.1 A Risk Sharing Model

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. The stochastic structure of log income for household i in village v at time t is made up of three components:[9] (1) a deterministic 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 $e_{i,v,t}$. In addition, measured income is affected by a multiplicative measurement error $r^y_{i,v,t}$. Both the measurement error and the transitory component are independent and identically distributed.[10] 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

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

[9] See for example, Meghir and Pistaferri (2004)

[10] A more flexible specification would allow for persistence in the transitory shock, but due to data constraints (we do not observe consecutive years of data), we would not be able to identify the persistence.

where $u_{i,v,t}$ are shocks to permanent income that are independent and identically distributed. The 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, we first 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.[11] 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 demographics and other time varying variables that might affect marginal utility, and $\mu_{v,t}$ is the multiplier associated to the resource constraint in a given state of the world for group v at time t.[12] If we assume that $\beta_{i,v,t} = e^{\theta z_{i,v,t}}$ and that the utility function is of the CRRA type with coefficient σ, taking the log of equation (4) gives:

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

Equation (5) is the basis for a standard test of perfect insurance (Townsend, 1994). We note that 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. Dividing by σ and appropriately adjusting individual log consumption for the taste shifters $z_{i,v,t}$, we can re-write this equation as:

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

[11] 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 study risk sharing *across* groups next.

[12] We note that equation (4) holds in any possible state of the world for group v at time t. The multiplier $\mu_{v,t}$ incorporates the probability of the particular state of the world considered.

where $c_{i,v,t} \equiv (\log C_{i,v,t} + \theta z_{i,v,t})/\sigma$ and $\epsilon_{i,v,t}$ reflects measurement error or unobserved taste shocks that affect the marginal utility of consumption. Within this specification, the perfect risk sharing hypothesis is that $\psi = 0$: 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 is to take the first difference over time of equation (6), which eliminates the individual fixed effect:

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

where once again the test of perfect insurance is $\psi = 0$.

The tests in equations (6) and (7) define the risk sharing group as the village and thus test for perfect insurance against income shocks *within* the village. They are silent, however, about insurance against shocks that are aggregate to the village, such as regional agricultural shocks. Considering, instead, the social planner problem for the entire economy (made up of many villages), we can additionally test for perfect risk sharing *across* villages. To do this, we define village-level averages of equations (6) and (7) to get:

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

and

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

where $\bar{y}_{v,t} \equiv \frac{1}{N_v} \sum_{i=1}^{N_v} y_{i,v,t}$ and N_v is the number of households in each village v. 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), (7), (8) and (9) for different time periods to document how deviations from perfect risk sharing (within and across villages) has changed over time.

3.2 How Different Components of Income Are Reflected in Consumption

An important limitation of the tests in equations (6) through (9) is that they do not explicitly differentiate between different components of the income process, such as the temporary and permanent components.[13] To investigate more precisely the mechanisms underpinning the lack of complete risk sharing, we can decompose the lack of insurance stemming from permanent income shocks from the lack of insurance stemming from temporary shocks using the partial insurance framework of Blundell, Pistaferri, and Preston (2008) and extended by Attanasio, Meghir, and Mommaerts (2015) to allow for insurance within risk-sharing groups. Starting from the specification of income in equation (1) and (2), Blundell, Pistaferri, and Preston (2008) show that in a simple life-cycle model of consumption, unexplained innovations to consumption can be approximated as a function of the unexplained innovations to income:

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

where δ measures the degree to which permanent shocks pass through to consumption and γ measures the degree to which transitory shocks pass through to consumption. In addition, $r^{c}_{i,v,t}$ represents classical measurement error and $\xi_{i,v,t}$ represents permanent innovations to consumption that are independent of income, such as innovations to preferences. Under perfect risk sharing, just as in the tests in Section 3.1, both δ and γ would be equal to zero.

To allow for the distinction between village level aggregate shocks and idiosyncratic shocks in the partial insurance model, we express the income process in equation (3) in terms of village-average components and the deviation of the household shock from the village average. In particular, we define $u^{V}_{v,t}$ as the aggregate permanent shock to village resources for village v, and $u^{I}_{i,v,t}$ as the idiosyncratic permanent shock to household i in village v, such that $u^{V}_{v,t} + u^{I}_{i,v,t} = u_{i,v,t}$.[14] Analogously, let $e^{V}_{v,t} + e^{I}_{i,v,t} = e_{i,v,t}$ for transitory shocks. Then rewriting equation (3), the growth

[13] Having said that we notice that equations (6) and (7) have different power against slightly 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 temporary 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 temporary shocks. It is clear, therefore, that the failure to insure permament shocks will be more apparent when estimating equation (6), while temporary shocks will be more visible in equation (7).

[14] By definition, it must be the case that the sum of the idiosyncratic shocks across village members is zero for both permanent and transitory shocks: $\sum_{i=1}^{n_v} u^{I}_{i,v,t} = 0$ and $\sum_{i=1}^{n_v} e^{I}_{i,v,t} = 0$. There is no loss of generality and no particular restriction implied by the way we have written equation (11).

in log (unexplained) income is:

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

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. 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 growth in log (unexplained) consumption, as:

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

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 adult-equivalent income and consumption on a set of demographics to isolate the residual, unexplained income and consumption.[15] Second, we estimate the variances of the income parameters of equation (11), allowing them to differ by sub-periods 1989-1997 and 1998-2009.[16] 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

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

[16]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.

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.[17] The survey covers nine geographically diverse provinces that are at various stages of economic development, and is designed to track the nutritional and health status of the Chinese population and evaluate the health, nutrition, and family planning policies and programs implemented by national and local governments. There are eight waves spanning 1989 to 2009, conducted in 1989, 1991, 1993, 1997, 2000, 2004, 2006, and 2009. We restrict our sample to rural households.[18]

From the detailed data on household production activities and labor market experience, we construct a measure of household disposable income, which includes agricultural income (from farming, gardening, livestock raising and fishing), non-agricultural business income, capital income (from land lease and asset rentals), labor market income, and public and private transfers. We take advantage of the diaries on food consumption, whose quality is suitable for nutrition study, to construct our measure of household food consumption, which is our baseline household consumption measure.[19] We restrict the sample by trimming the top and bottom 1% of the income and consumption 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 the analysis sample are found in Table 2. There are an average of 17

[17]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.

[18]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.

[19]In Appendix D, 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.

Table 2: Summary Statistics, CHNS (1989-2009), Selected Waves

	1989	2000	2009
Panel A: Household-level			
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 kids 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)
No education	12.49	6.67	3.53
	(33.07)	(24.95)	(18.46)
Below 9th grade	72.87	77.89	76.62
	(44.48)	(41.51)	(42.34)
Above 9th grade	14.64	15.44	19.84
	(35.36)	(36.15)	(39.90)
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		17.03	
		(2.36)	
Panel B: Village-level			
Population	2137	2031	2617
	(1706)	(1580)	(2092)
Area (square kilometers)	7.71	9.79	7.83
	(38.56)	(47.38)	(25.00)
Number of households	–	502	746
		(393)	(620)
Migrant workers (% of workforce)	20.48	27.29	31.16
	(20.83)	(21.48)	(23.14)
Number of unique villages		149	
Number of village-year observations		1084	

Standard deviations in parentheses. See text for income and consumption definitions. The number of households in a village is surveyed from 1991 to 2009.

sampled households per village. 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. Households are predominantly headed by a male and are of Han ethnicity. The level of educational achievement of the head improved over the sample period, but even in 2009 about 80% of the heads have educational levels that are below the nine years of compulsory (free public) education.[20] The average annual household disposable income increased threefold, from $1,110 to $4,011 (in 2009 USD). Comparing that to the household income excluding private transfers, we observe that private transfers account for a relatively small fraction of disposable income. 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.

Village-level summary statistics are shown in Panel B of Table 2.[21] The average village population increased slightly from 2,137 households in 1989 to 2,617 households by the end of the sample period. The average area of a village is less than 10 square kilometers. The number of households in a village increased from just below 500 households in the 1990s to 746 households in 2009. There was a steady increase in the percentage of migrants in a village, from 20.48% in 1989 to 31.16% in 2009.[22] The standard deviation in the parenthesis indicates substantial heterogeneity in terms of these village characteristics across the sample.

5 Empirical Results on Changes in Risk Sharing over Time

In this section, we present the results of our empirical analysis of the risk sharing models described in Section 3. 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.

[20] The nine years of compulsory education was written into law in 1986. However, the heads in our sample almost all come from earlier cohorts who did not benefit from the law.

[21] This information is collected in the Community Survey of the CHNS. In particular, the interviewee, i.e. someone who is knowledgeable about the village affairs, is asked about the basic facts about the village: the population of the village, the area of the village, and the number of households in the village.

[22] 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 a simple test of full consumption insurance, in the spirit of Townsend (1994), using the data described in Section 4. In particular, we estimate equation (6), which tests perfect risk sharing *within villages*, and (8), which considers risk sharing *across villages*. We also analyse how the parameters of these equations have changed over time.

Table 3: Tests of Full Consumption Insurance at the Household and Village Level

	Log household food		Log average household food	
	(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)		
Log average household income			0.119***	
			(0.028)	
Log average household income x pre-1998				0.064
				(0.053)
Log average household income x post-1998				0.154***
				(0.038)
Observations	12881	12881	1084	1084
R-squared	0.631	0.632	0.681	0.684

Note: Regressions in columns (1) and (2) 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) use average household level income and food consumption aggregated to the village level, control for province-year fixed effects and village fixed effects, and standard errors (in parentheses) are clustered by province. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Columns (1) and (2) of Table 3 report the estimates of equation (6): a 10% increase in household income is associated with a 0.75% increase in household consumption: households are quite well insured but not fully so, with the test firmly rejecting full insurance.[23] Column (2) interacts log income with two sub-periods in our data: 1989-1997, which was marked by 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 first sub-period, while consumption insurance eroded in the second sub-period, the difference being significant.

Columns (3) and (4) report the results obtained in estimating equation (8), focusing on insurance

[23] With measurement error, this estimate is in fact a *lower* bound of the correlation between income and consumption.

across villages. In particular, we regress the average log of consumption in a village, on village average log income, controlling for village fixed effects and year fixed effects. Once again, perfect insurance at the village level is firmly rejected. Moreover, the correlation between village-aggregated income and consumption is substantially higher in the second sub-period, mirroring the results at the household level.

Having tested full risk sharing in levels, Table 4 reports the tests in first differences (equations (7) and (9)). These results also suggest that both within-village and across-village insurance eroded over time. We note, however, that the estimates of the coefficient in the village average regression equation (9), are estimated quite imprecisely, and are only marginally significant in the first period.

Table 4: First Difference Tests of Full Consumption Insurance

	Change in log household food		Change in log average household food	
	(1)	(2)	(3)	(4)
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)		
Change in log average household income			0.078*	
			(0.036)	
Change in log average household income x pre-1998				0.078*
				(0.039)
Change in log average household income x post-1998				0.077
				(0.054)
Observations	9072	9072	916	916
R-squared	0.292	0.293	0.288	0.288

Note: Regressions in columns (1) and (2) use changes over time in household level income and food consumption, control for village-year fixed effects, and standard errors (in parentheses) are clustered by village. Regressions in columns (3) and (4) 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. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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 Table 5. Since measurement error in income is not separately identified from the transitory idiosyncratic

shocks, we experiment with different assumptions on the level of income measurement error across the columns of Table 5: we set σ_y^2 to 0.01, 0.05 and 0.1.

Table 5: Income Parameter Estimates (Various Measurement Error Assumptions)

	(1) M.E.=0.01	(2) M.E.=0.05	(3) M.E.=0.1
The 1989-1997 period			
Idiosyncratic shock variances			
Permanent	0.027	0.027	0.027
	(0.012)	(0.012)	(0.012)
Transitory	0.357	0.320	0.274
	(0.027)	(0.027)	(0.027)
Village-aggregate shock variances			
Permanent	0.026	0.026	0.026
	(0.005)	(0.005)	(0.005)
Transitory	0.034	0.031	0.027
	(0.007)	(0.007)	(0.007)
Percent insurable by village			
Permanent	0.504	0.507	0.512
	(0.130)	(0.129)	(0.129)
Transitory	0.913	0.912	0.910
	(0.017)	(0.019)	(0.023)
The 1998-2009 period			
Idiosyncratic shock variances			
Permanent	0.034	0.034	0.034
	(0.011)	(0.011)	(0.011)
Transitory	0.425	0.389	0.344
	(0.028)	(0.028)	(0.028)
Village-aggregate shock variances			
Permanent	0.024	0.024	0.023
	(0.005)	(0.005)	(0.004)
Transitory	0.047	0.043	0.039
	(0.008)	(0.008)	(0.008)
Percent insurable by village			
Permanent	0.587	0.589	0.591
	(0.088)	(0.088)	(0.087)
Transitory	0.900	0.900	0.899
	(0.018)	(0.019)	(0.022)

Note: Standard errors in parentheses are based on 50 block bootstrap replications, clustered by village.

The results are similar across the two periods. Transitory shocks are predominantly idiosyncratic, with the village-aggregate transitory shocks accounting for about 10% of the total variance, and hence the majority 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.

It is worth pointing out that the sizeable fraction of permanent shocks that are aggregate to the village requires us to look beyond the usual suspects for sources of permanent income shocks – e.g. changes in health conditions, career, and family formation/dissolution – and to explore the changing local economic conditions as a potentially important source. Examples of village-aggregate permanent shocks include the opening or closing of a TVE, converting land into non-agricultural uses, completion of a major infrastructure project close to the village, and changing of the administrative status of the village, to name a few. This also implies that it could be particularly difficult to insure against village-aggregate permanent shocks in that only insurance arrangements from outside of the village can help smooth those shocks, leaving a potential role for public insurance coordinated at a higher-level government such as townships and counties.

From now on, we fix the variance of the measurement error in income at 0.05 and take it as our benchmark specification. Reassuringly, different values of income measurement error have minimal effects on the income parameter estimates. In particular, the estimates of the variance of the permanent shocks, which are economically more relevant, are robust to alternative measurement error settings. The choice of 0.05 is roughly 30% of the average variance of annualized income growth across the waves in the sample period, which is 0.17. In percentage terms, this is slightly higher than those estimated using micro data (Bound and Krueger, 1994; Bound, Brown, Duncan *et al.*, 1994) and those used by Meghir and Pistaferri (2004) for the United States.

The Transmission of Shocks. Next we report the transmission parameters from equation (12) of the partial insurance model in the second column of Table 6.[24] In the 1989-1997 sub-period, none of the transmission parameters of various types of income shocks is significant. This is consistent with the findings of Santaeulàlia-Llopis and Zheng (2018) that one cannot reject the null of perfect insurance in rural China in the 1990s. Given the lower precision of these estimates compared to our estimates from Section 5.1, it is also consistent with the findings in Section 5.1 that show small but significant transmission of idiosyncratic income shocks to consumption. In the 1998-2009 period, however, this changes. In particular the transmission of the idiosyncratic transitory shock and of the village-aggregate permanent shocks become significantly positive. The transmission of the idiosyncratic transitory shocks is a low yet significant 0.041, while the transmission of the

[24] Appendix Table 5 reports the estimates for the household total consumption measure, which are very similar.

village-level permanent shocks is a significant 0.619.

Table 6: Estimates of Partial Insurance Model

	Income variances	Food transmissions
Panel A: Parameter estimates		
The 1989-1997 period		
Idiosyncratic shocks		
Permanent	0.027	0.042
	(0.012)	(0.029)
Transitory	0.320	0.000
	(0.027)	(0.003)
Village-aggregate shocks		
Permanent	0.026	0.018
	(0.005)	(0.079)
Transitory	0.031	0.000
	(0.007)	(0.252)
The 1998-2009 period		
Idiosyncratic shocks		
Permanent	0.034	0.120
	(0.011)	(0.101)
Transitory	0.389	0.041
	(0.028)	(0.022)
Village-aggregate shocks		
Permanent	0.024	0.619
	(0.005)	(0.231)
Transitory	0.043	0.000
	(0.008)	(0.284)
Panel B: χ^2 test of differences over time		
Idiosyncratic shocks		
Permanent	0.35	0.58
	(0.55)	(0.45)
Transitory	5.69	3.57
	(0.02)	(0.06)
Village-aggregate shocks		
Permanent	0.16	5.09
	(0.69)	(0.02)
Transitory	1.52	0.00
	(0.22)	(1.00)
Joint test	13.93	17.31
	(0.01)	(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 (Column (2) in Table 5). 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 test is of all 4 pairwise comparisons in the column.

In Panel B, we test the differences of the parameter estimates in the two sub periods. A null hypothesis of the four types of income shocks all remaining constant in the two sub periods can be strongly rejected (the joint test in the last row). Of the four types of income shocks, the idiosyncratic transitory shock increased significantly (with a p-value of 0.02) from 0.320 in the first sub period to 0.389 in the second sub period, which corresponds to a 22% increase. Of the transmission

parameters, the pass-through of the idiosyncratic transitory shock increased significantly (with a p-value of 0.06) from 0.000 to 0.041 and the increase of the pass-through of the village-aggregate permanent shock increased significantly (with a p-value of 0.02) from 0.018 to 0.619. 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, even explicitly controlling for measurement error, as we do here.

The lack of insurance against the village-aggregate permanent shocks in the 2000s marks a striking departure from rural China's collective past. Nevertheless, households managed to achieve partial insurance against even permanent shocks, and within-village risk sharing was an important source of this partial insurance. 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 is 0.120, while that of the village-aggregate permanent shock is 0.619. These point estimates are significantly different. This suggests that village insurance networks, though imperfect, help smooth 49.9% of permanent income shocks.

The Welfare Costs of the Decline in Insurance. We next use the results from Table 6 to quantify the welfare loss related to the documented changes in 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. To do this, we assume CRRA utility and derive analytical formulas for consumption equivalents similar to Santaeulàlia-Llopis and Zheng (2018) (see Appendix C for our particular derivations).

Table 7 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.[25] 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 7 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 erosion of insurance against village-aggregate shocks.

Table 7: 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: 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 C for the welfare derivations.

In sum, our analysis reveals that rural households in China faced significantly higher levels of idiosyncratic transitory risk over the course of growth 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 to shed light on the mechanisms underlying the two main findings in Section 5.2 that insurance against both idiosyncratic and aggregate shocks has

[25]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.

eroded over time. First, we exploit provincial variation in collective activities at the village level to show that higher levels of (household) consumption insurance are associated with having a larger presence of community-based activities (such as industrial production in a TVE or agricultural production). The community-based activities naturally tie villagers' lives closer together, reduce informational asymmetries, and increase the cost of breaking commitment. We show that differences across provinces and over time in the prevalence of these activities in a village is associated with differences in consumption insurance, particularly against idiosyncratic shocks. Any formal insurance mechanism that insures against village-aggregate risk across villages, on the other hand, needs to be coordinated at a higher administrative level. To that end, we investigate the evolution of inter-governmental transfer programs to look for evidence for declining insurance. Using a rare data opportunity of county-level fiscal data, we show that the role of various inter-governmental transfers as a source of insurance declined over the sample period, with each locality's public good provision more exposed to local output risks than before.

6.1 The Weakening of Within-Village Insurance

As discussed in Section 2, our sample period captures a period of major economic transformation in rural China, including the transition out of agriculture and the decline of the TVEs, both of which are examples of collective production activities that tied rural households to their villages. Meanwhile, the share of temporary migrants in the village steadily increased from 20% in 1989 to 31% in 2009 (Table 2), which may have further weakened these ties. These economic changes have the potential to disrupt the informal risk sharing arrangements that are embedded in a relatively static and closed rural society.

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 four village characteristics aggregated to the province level:[26] (1) the average percent of the village population working in agriculture, (2) the average percent of the village population engaged in temporary migration, (3) the average number of TVEs in a village, and (4) the average share of TVE revenue spent on public goods in a village. Denoting these

[26]In CHNS, the next level of aggregation above the village is the province. Due to data confidentiality, we do not observe the identity of the county or the prefecture that a village is located in.

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):

$$c_{ivpt} = \sum_{r=0,1} \Big(\psi_{0,r} y_{ivpt} \times \{\text{post} = r\} + \psi_{1,r} y_{ivpt} X_{pt} \times \{\text{post} = r\} \Big) + \tilde{\pi}_{ivp} + \nu_{vpt} + \varepsilon_{ivpt} \qquad (13)$$

As before, 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 allow the coefficients $\psi_{0,r}$ and $\psi_{1,r}$ to vary by pre-1998 (post=0) and post-1998 (post=1). 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.

The results are reported in Table 8. 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 (5) 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 village population works in agriculture, while column (3) shows that households are more poorly insured by villages in provinces where a higher share of village population engages in temporary migration. Columns (4) and (5) show that households are also better insured by villages in provinces where villages have more collective enterprises (TVEs) and where a higher share of TVE revenue is spent on public goods in the village. Finally, column (6) 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 temporary migration, and the dissolution of TVEs were prominent features of the economic transformation of rural China (Section 2), and the results in Table 8 suggest that within-village insurance against household-level income risk declined most where these changes were most marked. In contrast, when we repeat this exercise using average food consumption and income averaged to the village level (Appendix Table 4 in Appendix D), 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

Table 8: Consumption Smoothing, Interacted with Provincial Characteristics

	Log household food consumption					
	(1)	(2)	(3)	(4)	(5)	(6)
Log household income x pre-1998	0.043***	0.054	0.051	0.038	0.050***	0.099
	(0.010)	(0.059)	(0.041)	(0.026)	(0.012)	(0.098)
x Province avg agriculture		-0.000				-0.000
		(0.001)				(0.001)
x Province avg migration			-0.000			-0.001
			(0.002)			(0.002)
x Province avg collective enterprises				0.000		0.000
				(0.001)		(0.001)
x Province avg pct revenue to public good					-0.002	-0.003
					(0.003)	(0.003)
Log household income x post-1998	0.100***	0.191***	-0.025	0.138***	0.119***	0.115*
	(0.012)	(0.038)	(0.039)	(0.020)	(0.013)	(0.067)
x Province avg agriculture		-0.002***				-0.001*
		(0.001)				(0.001)
x Province avg migration			0.004***			0.003*
			(0.001)			(0.001)
x Province avg collective enterprises				-0.002***		-0.001
				(0.001)		(0.001)
x Province avg pct revenue to public good					-0.011***	-0.008*
					(0.004)	(0.004)
Mean interacted variable, pre-1998		59.24	20.08	56.59	3.476	
SD interacted variable, pre-1998		12.53	5.757	17.62	4.922	
Mean interacted variable, post-1998		50.85	29.96	21.42	1.897	
SD interacted variable, post-1998		14.19	7.600	15.75	2.734	
F-stat, pre-1998 interactions						0.412
F-stat, post-1998 interactions						5.722
Observations	12881	12881	12881	12881	12881	12881
R-squared	0.632	0.632	0.633	0.632	0.633	0.633

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)-(6) also interacted with provincial averages of village economic conditions. Means and standard deviations of the interacted variables in columns (2)-(5), and F-stats of the interaction terms by pre/post in column (6), are in the lower panel of the table. Standard errors in parentheses are clustered by village. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

entail moving resources across villages, which likely coordination 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 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 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 transferred resources to fiscally poor localities to achieve a greater degree of redistribution and risk sharing. In particular, the "general transfer" programs provide long-term periodic funds aimed at geographical redistribution and risk-sharing, while "special transfer" programs provide ad hoc transfers to facilitate specific central policies.[27] From county governments downwards, resources are meant to flow to townships and villages to balance redistribution, risk-sharing, and development goals. With the disintegration of TVEs, this system became the primary formal insurance mechanism for households against village-aggregate risk.

To investigate the role of intergovernmental transfers on insurance against aggregate shocks, 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.[28] 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 9 reports summary statistics at several points in time (converted to 2009 US 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 less than 9%

[27]Some examples of special transfers include subsidies for agricultural development, support for infrastructure construction, and natural disaster relief funds.

[28]Our data is downloaded 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.

of total revenue in 1994 to over 25% 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 9: Summary Statistics, Fiscal Balance Sheet of Counties

	1994	1997	2002	2007
Output	2,903	3,290	4,978	11,003
	(3,087)	(3,597)	(5,438)	(13,261)
Fiscal revenues				
Total fiscal revenues	177	230	423	1,153
	(156)	(206)	(388)	(1,047)
Tax revenues	128	161	243	573
	(131)	(160)	(310)	(839)
General transfers received	15.42	16.94	98.71	308.19
	(12.71)	(16.55)	(72.96)	(201.01)
Special transfers received	26.90	32.61	51.14	195.29
	(19.88)	(26.45)	(38.12)	(127.72)
Other revenues	14.74	27.66	28.07	56.75
	(27.71)	(42.97)	(48.16)	(80.33)
Fiscal expenditures				
Total fiscal expenditures	187	230	433	1,100
	(163)	(202)	(388)	(980)
Local expenditures	150	189	394	1,002
	(103)	(145)	(333)	(803)
General transfers contributed	60.57	42.55	45.25	48.59
	(92.96)	(64.26)	(69.59)	(124.39)
Special transfers contributed	5.64	8.67	21.71	49.77
	(9.12)	(12.21)	(36.52)	(125.62)
Other expenditures	12.69	23.64	10.58	7.15
	(15.17)	(29.42)	(16.84)	(12.94)
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 the main variables from the county-level panel. All economic variables are in thousand 2009 US dollars. 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 strategy to equation (6) and 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 10: Effect of output on components of fiscal transfers and county fiscal 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 transfer data is missing for some years and some counties. All regressions control for county population, county fixed effects and province-year fixed effects. Standard errors in parentheses are clustered by county. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10 reports the γ coefficients from Equation (14) for outcomes including tax revenue, local expenditures, net general transfers, and net special transfers.[29] 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 rows show that counties with higher output get lower net general transfers and net special transfers, but this negative correlation is less prominent in the later period. The final row shows a similar pattern as the first row: 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.

Our interpretation of these results is that county governments are increasingly self-reliant to satisfy their fiscal spending needs, leaving counties which are hit by bad economic shocks increas-

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

ingly vulnerable. Even if resources are allocated on a full insurance basis from county down to villages, the evidence for declining within-province insurance across counties corroborates the declining within-province insurance across villages observed in Table 6. 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 shocks.

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, all of which correlate with higher income. 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 as large as a county. With the rising regional inequality, local governments are left to themselves for insurance, which makes village aggregate income risk increasingly difficult to insure.

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. 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 is trimmed top and bottom 1% of the income and consumption distribution 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.[30] 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.[31] The variable, *general transfer received*, is

[30]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.

[31]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 1997-200, 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 41,994 county-year observations. Finally, we deflate all economic variables by province-level CPI (2009=100) and transform all it to 2009 USD 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

We follow Attanasio, Meghir, and Mommaerts (2015) in identification of the model, which involves a total of 20 parameters (10 for each time period): 8 income variances, 8 transmission parameters, 2 consumption measurement error variances, and 2 consumption heterogeneity variances. In this appendix we show identification under the assumption of consecutive years of data; the moments in our data are not consecutive, which require slight modifications of the moments below (details of the identification proof for non-consecutive data is available upon request).

We first show identification of the 8 income variances, then the consumption parameters.

Income parameters

We first define village-average income by aggregating equation (11) within a village:

$$\overline{\Delta y_{i,j,t}} = u^V_{j,t} + \Delta e^V_{j,t} + \frac{1}{n_j}\sum_{i=1}^{n_j} \Delta r^y_{i,j,t} \tag{15}$$

We then use the following covariances for identification:

$$\text{cov}(\Delta y_{i,j,t}, \Delta y_{i,j,t}) = \text{var}(u^V_t) + \text{var}(u^I_t) + 2\text{var}(e^V_t) + 2\text{var}(e^I_t) + 2\text{var}(r^y) \tag{16}$$

$$\text{cov}(\Delta y_{i,j,t}, \Delta y_{i,j,t+1}) = -\text{var}(e^V_t) - \text{var}(e^I_t) - \text{var}(r^y) \tag{17}$$

$$\text{cov}(\overline{\Delta y_{i,j,t}}, \overline{\Delta y_{i,j,t}}) = \text{var}(u^V_t) + 2\text{var}(e^V_t) + \frac{2}{n_j}\text{var}(r^y) \tag{18}$$

$$\text{cov}(\overline{\Delta y_{i,j,t}}, \overline{\Delta y_{i,j,t+1}}) = -\text{var}(e^V_t) - \frac{1}{n_j}\text{var}(r^y) \tag{19}$$

Since we set $\text{var}(r^y) = 0.05$, $\text{var}(e^V_t)$ is then identified from (19), and with that then $\text{var}(e^I_t)$ is identified from (17) and $\text{var}(u^V_t)$ is identified from (18). Finally, $\text{var}(u^I_t)$ is identified from (16).

Consumption parameters

Similar to income, we define village-average consumption by aggregating equation (12) within a village:

$$\overline{\Delta c_{i,j,t}} = \delta_V u^V_{j,t} + \gamma_V e^V_{j,t} + \frac{1}{n_j}\sum_{i=1}^{n_j}\left(\Delta r^c_{i,j,t} + \xi_{i,j,t}\right) \tag{20}$$

We then use the following covariances for identification:

$$\text{cov}(\Delta c_{i,j,t}, \Delta c_{i,j,t}) = \delta_I^2 \text{var}(u_t^I) + \delta_V^2 \text{var}(u_t^V) + \gamma_I^2 \text{var}(e_t^I) + \gamma_V^2 \text{var}(e_t^V) + 2\text{var}(r_t^c) + \text{var}(\xi_t) \quad (21)$$

$$\text{cov}(\Delta c_{i,j,t}, \Delta c_{i,j,t+1}) = -\text{var}(r_t^c) \quad (22)$$

$$\text{cov}(\Delta c_{i,j,t}, \Delta y_{i,j,t}) = \delta_I \text{var}(u_t^I) + \delta_V \text{var}(u_t^V) + \gamma_I \text{var}(e_t^I) + \gamma_V \text{var}(e_t^V) \quad (23)$$

$$\text{cov}(\Delta c_{i,j,t}, \Delta y_{i,j,t+1}) = -\gamma_I \text{var}(e_t^I) - \gamma_V \text{var}(e_t^V) \quad (24)$$

$$\text{cov}(\overline{\Delta c_{i,j,t}}, \overline{\Delta c_{i,j,t}}) = \delta_V^2 \text{var}(u_t^V) + \gamma_V^2 \text{var}(e_t^V) + \frac{2}{n_j} \left(\text{var}(r_t^c) + \text{var}(\xi_t)\right) \quad (25)$$

$$\text{cov}(\overline{\Delta c_{i,j,t}}, \overline{\Delta c_{i,j,t+1}}) = -\frac{1}{n_j} \text{var}(r_t^c) \quad (26)$$

$$\text{cov}(\overline{\Delta c_{i,j,t}}, \overline{\Delta y_{i,j,t}}) = \delta_V \text{var}(u_t^V) + \gamma_V \text{var}(e_t^V) \quad (27)$$

$$\text{cov}(\overline{\Delta c_{i,j,t}}, \overline{\Delta y_{i,j,t+1}}) = -\gamma_V \text{var}(e_t^V) \quad (28)$$

Equations (22) or (26) identify $\text{var}(r_t^c)$. Since we have already identified income variances, (28) identifies γ_V and then it follows that (24) identifies γ_I and (27) identifies δ_V. Then (23) identifies δ_I. Finally, (21) or (25) identifies $\text{var}(\xi_t)$.

Appendix C Derivation of Welfare Formula

In this appendix we derive the consumption equivalent formula used to compute the welfare declines reported in Table 7. 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 fact that the terms inside the exp() function are distributed with mean zero and variance $(1-\eta)^2(\delta_I^2\sigma^2_{u^I} + \delta_V^2\sigma^2_{u^V} + \gamma_I^2\sigma^2_{e^I} + \gamma_V^2\sigma^2_{e^V} + \sigma^2_{r^c} + \sigma^2_\xi)$.

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:

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

Appendix D Additional Tables

We regress the village aggregate household food consumption on the 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 4. 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 the village characteristics such as share of agriculture, migrants, and TVEs can no longer 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.

In Appendix Table 5, we repeat our baseline estimation of the partial insurance using total consumption instead of food consumption as the consumption measure. The 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 using household consumption measure are very similar to our baseline results using household food consumption measure.

Appendix Table 4: Village version

	Log average household food consumption					
	(1)	(2)	(3)	(4)	(5)	(6)
Log average household income x pre-1998	0.064*	0.332**	0.170*	-0.100	0.060	0.510*
	(0.033)	(0.142)	(0.099)	(0.102)	(0.038)	(0.284)
x Province avg agriculture		-0.005**				-0.006**
		(0.002)				(0.003)
x Province avg migration			-0.005			-0.008
			(0.005)			(0.005)
x Province avg collective enterprises				0.003*		0.001
				(0.002)		(0.002)
x Province avg pct revenue to public good					0.001	-0.005
					(0.004)	(0.004)
Log average household income x post-1998	0.154***	0.211**	0.316**	0.086	0.132***	0.385*
	(0.031)	(0.099)	(0.130)	(0.052)	(0.033)	(0.206)
x Province avg agriculture		-0.001				-0.003
		(0.002)				(0.002)
x Province avg migration			-0.005			-0.006
			(0.004)			(0.004)
x Province avg collective enterprises				0.003*		0.003
				(0.002)		(0.002)
x Province avg pct revenue to public good					0.012	-0.001
					(0.010)	(0.011)
Mean interacted variable, pre-1998		59.35	19.85	56.39	3.580	
SD interacted variable, pre-1998		12.77	5.691	18.09	5.124	
Mean interacted variable, post-1998		50.69	29.87	21.00	1.809	
SD interacted variable, post-1998		13.95	7.442	15.37	2.742	
F-stat, pre-1998 interactions						2.375
F-stat, post-1998 interactions						1.248
Observations	1084	1084	1084	1084	1084	1084
R-squared	0.684	0.685	0.685	0.686	0.684	0.689

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)-(6) also interacted with provincial averages of village economic conditions. Means and standard deviations of the interacted variables in columns (2)-(5), and F-stats of the interaction terms by pre/post in column (6), are in the lower panel of the table. Standard errors in parentheses are clustered by village. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 5: Estimates of Partial Insurance Model, Total Consumption

	Income variances	Consumption transmissions
Panel A: Parameter estimates		
The 1989-1997 period		
Idiosyncratic shocks		
Permanent	0.027	0.042
	(0.012)	(0.035)
Transitory	0.320	0.000
	(0.027)	(0.007)
Village-aggregate shocks		
Permanent	0.026	0.122
	(0.005)	(0.162)
Transitory	0.031	0.000
	(0.007)	(0.149)
The 1998-2009 period		
Idiosyncratic shocks		
Permanent	0.034	0.120
	(0.011)	(0.104)
Transitory	0.389	0.044
	(0.028)	(0.020)
Village-aggregate shocks		
Permanent	0.024	0.599
	(0.005)	(0.252)
Transitory	0.043	0.000
	(0.008)	(0.262)
Panel B: χ^2 test of differences over time		
Idiosyncratic shocks		
Permanent	0.35	0.52
	(0.55)	(0.47)
Transitory	5.69	5.17
	(0.02)	(0.02)
Village-aggregate shocks		
Permanent	0.16	2.41
	(0.69)	(0.12)
Transitory	1.52	0.00
	(0.22)	(1.00)
Joint test	13.93	10.06
	(0.01)	(0.04)

Note: Also estimated are consumption heterogeneity and consumption measurement error, both for the pre-period and post-period (not shown). Income measurement error is set to 0.05 (Column (2) in Table 5). 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 test is of all 4 pairwise comparisons in the column.

Small letters are logs. Suppose that income is a standard transitory + permanent.

$$y_{i,t} = p_{i,t} + u_{i,t}$$

$$p_{i,t} = p_{i,t-1} + v_{i,t}$$

the f.o.c. under perfect risk sharing implies (under log utility - but something similar can be obtained with more general CRRA pref):

$$c_{i,t} = \nu_t + \pi_i + \epsilon_{i,t}$$

where ν_t is the multiplier for the aggregate resource constraint and π_i the pareto weight.

The standard Townsend test in levels will be:

$$c_{i,t} = \nu_t + \pi_i + \lambda y_{i,t} + \epsilon_{i,t} = c_{i,t} = \nu_t + \pi_i + \lambda(p_{i,t} + u_{i,t}) + \epsilon_{i,t}$$

where under the null $\lambda = 0$.

Taking first differences we get:

$$\Delta c_{i,t} = \Delta\nu_t + \lambda\Delta\ y_{i,t} + \Delta\epsilon_{i,t} = \Delta\nu_t + \lambda\Delta y_{i,t} + \Delta\epsilon_{i,t} = \Delta\nu_t + \lambda(v_{i,t} + \Delta u_{i,t}) + \Delta\epsilon_{i,t}$$

Taking the kth differences we get:

$$\begin{aligned}\Delta_k c_{i,t} =& \Delta_k\nu_t + \lambda\Delta_k\ y_{i,t} + \Delta_k\epsilon_{i,t} \\ =& \Delta\nu_t + \lambda\Delta y_{i,t} + \Delta\epsilon_{i,t} \\ =& \Delta\nu_t + \lambda(v_{i,t} + v_{i,t-1} + ... + v_{i,t-k} + \Delta_k u_{i,t}) + \Delta_k\epsilon_{i,t}\end{aligned}$$

As you can see, as k increases, the variability of the income term is determined by the variance of the permanent shocks proportionally more than the variance of transitory shocks.

Appendix Table 6: First differences townsend, short and long spacing

	Short panels		Long panels	
	(1)	(2)	(3)	(4)
Change in log household income	0.054***		0.070***	
	(0.011)		(0.012)	
Change in log household income x pre-1998		0.020		0.043***
		(0.013)		(0.015)
Change in log household income x post-1998		0.075***		0.093***
		(0.015)		(0.018)
Observations	6756	6756	4538	4538
R-squared	0.292	0.293	0.296	0.297