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Abstract

The empirical literature on household savings tends to treat savings simply as the residual of income minus consumption. This paper takes a unique approach to reconstruct the cash and asset balances using detailed household transaction data on farm households in rural India and generates monthly and seasonal ICRISAT panel data for the period 1976-1983. We have found that households - irrespective of their landholding status - cope with temporary shocks quite well by using crop inventory, currency and capital assets, rather than livestock, as buffer assets. The importance of portfolio adjustments in smoothing consumption is also confirmed by the use of a system of equations in which both portfolio and production decisions are made endogenous. It is concluded that not only the level but also the diversification of household assets are important for buffering consumption. As an extension, we have explored the monthly ICRISAT panel data for the period 2009-2012 in the same villages and have found a similar pattern in household portfolio responses to income shocks.

The JEL codes: O16, D12, C33

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1. Introduction

The traditional literature on savings and consumption smoothing has focused on the aspect of ‘buffer-stock’ savings in contrast to the traditional literature of life-cycle saving by modelling either the liquidity constraints of households (Deaton, 1990, 1991, 1992, 1997, Zeldes, 1989) or the precautionary nature of savings (e.g., Kimball, 1990, Carroll, 1997). Buffer-stock savings are particularly important in investigating rural poverty in developing countries because of the salient features of rural economy associated with its uncertainty or risk, e.g., due to the dependence on the agricultural sector, poor health services, low level of sanitation, and lack of access to formal credit. All of these factors combined lead to welfare deterioration among the poor and their economic development (Carter and Lybbert, 2012). However, most of the previous studies, except a few (e.g. Carter and Lybbert), treat savings simply as the residual of income minus consumption. The main aim of the current study is to shed a light on the “black box” by disaggregating the savings into various subcomponents and examine the extent to which households in rural India buffer their consumption by adjusting their assets.

Much of the empirical literature has focused on the role of precautionary or buffer-stock savings for household risk-coping in the context of developing countries, in and outside India. For instance, using the annual ICRISAT data, Rosenzweig and Wolpin (1993) emphasize the role of bullocks for credit-constrained households in rural India as a buffer stock for consumption. One of their main findings is that sales of bullocks increase when income streams decrease, and *vice versa*. However, Lim and Townsend (1998), through a close investigation of how rural farming households financed their deficit based on the monthly ICRISAT data, conclude that livestock -

including bullocks and major capital assets - play little part in smoothing intertemporal shocks. They insist that buffer stock of crop inventory and currency, together with credit or insurance, are much more important. Chaudhuri and Paxson (1994), also using the monthly ICRISAT data in India, investigate the impact of seasonality in income on seasonality in consumption. They conclude that seasonal patterns in consumption are common across households within villages but are not related to income seasonality. Based on the seasonal data of rainfall, Jacoby and Skoufias (1998) reach a similar conclusion by estimating the household response to anticipated and unanticipated income shocks.

Outside India, Carter and Lybbert (2012) device a technique to understand the coexistence of consumption and asset smoothing regimes based on the poverty trap model of Barrett et al. (2011), assuming that assets are not merely buffer stocks, but contemporarily act as productive assets with positively-diminishing returns. They employ a Hansen threshold estimation method for data from rural Burkina Faso between 1981 and 1985, which is a period where households are faced with severe drought. Carter and Lybbert find that while those who are richer in assets - proxied by tropical livestock units - managed to smooth their consumption well, the asset poor households tend to preserve their assets and smooth their consumption limitedly. There exists a critical herd size threshold that separates households with high versus low consumption smoothing, and those with such high smoothing levels who rely primarily on livestock to achieve it (Carter and Lybbert, 2012). Lee and Sawada (2010) assess the precautionary savings motive, or “prudence”, in Pakistan, based on 14 rounds of survey from 1986 to 1991. Their results confirm the theory of precautionary savings behavior among Pakistani households, particularly among those facing liquidity constraints. Using the same sample as Carter and Lybbert (2012), Kazianga and Udry (2006) find little evidence of consumption smoothing behavior. They confirm that households with subsistence income in Burkina Faso do not liquidate their assets in favor of current consumption, and households who face land-income volatility to a greater extent save more given their income shocks. With the same dataset, Fafchamps et al. (1998) show that livestock sales did not adequately serve as precautionary savings, particularly against negative income shocks, such as drought. Drawing upon a data set from Thailand, Paxson (1992) concludes that most of the transitory income attributed to rainfall shock is saved, that is, the saving behavior of farmers accords with the theoretical predictions of buffer-stock savings. The literature suggests that household savings matter in risk-coping, but the role of livestock savings/dissavings is generally limited. In other words, household assets other than livestock are likely to be important.

The contribution of this paper to the above empirical literature is twofold. Firstly, we look at not just the change in stock of a single asset, such as bullocks, but also the *total* portfolio adjustment of households that face various risks: the possibility exists that the sale of bullocks and the purchase of other items, like consumer durables for instance, may take place simultaneously. In this paper, we focus on dynamic changes in the portfolio of households, such as those pertaining to livestock, production capital or consumer durables, which has been largely neglected in the empirical literature. Here, we empirically examine how households mitigate income risk by portfolio adjustment. Secondly, we explicitly take account of household portfolio adjustment by the system of equations in which 1) transitory income, changes in a variety of household assets, and expenditure are simultaneously estimated and, 2) some forms of savings, namely, changes in financial assets, agricultural inputs, and production capital are allowed to affect transitory income shocks. Most of the past literature on household savings assumes that savings in themselves do not affect income. However, in rural economies, this is not a realistic assumption, because 1) physical assets have roles of production assets as well as savings or accumulation, and 2) transitory changes in financial assets or credit availability are key factors to transitory income changes. The idea is similar to Behrman et al.'s (1997) study which incorporates the sequential decision-making process in agricultural production in estimating saving function.[1]

The rest of the paper is organized as follows. The next section discusses the ICRISAT Village Level Studies. The specifications and empirical results in which transitory and permanent income are decomposed appear in Section 3. Section 4 discusses the methodologies and results of the system of equations whereby portfolio adjustment effects are estimated. Section 5 summarizes the results based on more recent ICRISAT panel data. The last section offers our concluding remarks.

2. Data

In this study, we construct monthly data on income, consumption, savings, and credit using the ICRISAT data - both monthly and seasonal data - between 1975/76 and 1984/85.[2] This dataset is well-known for its high quality and influence in the emergence of several of development economics' core findings (Walker and Ryan, 1990; Dercon et al., 2013). The survey is structured in such a way that households are stratified according to their landholding classes. 40 households in each village consist of four classes: the landless, small farmers, middle farmers, and large farmers. Our analysis is based on the household transaction module, the production modules, the household member schedule and the general endowment schedule in the ICRISAT data set. One of the distinguished features of the ICRISAT data set is the unusually detailed information that the

[1] The main difference between our study and Behrman, Foster, and Rosenzweig' s (1997) is that while the former deals with the portfolio of the entire household savings, the latter uses only a component of the savings, namely 1) net changes in financial assets, 2) net borrowing, and 3) transfers to friends and relatives.

[2] The first year (1975/76) and the final two years (1983/84-1984/85) have been dropped from the final estimations taking account of the consistency between the data recorded in the transaction modules and the income or consumption data.

household transaction module records.[3] As the contribution of the analysis in this paper is closely associated with the use and adjustment of data in the transaction module, we first briefly describe its features.

The main purposes of the transaction module are to assess the income position of households, to compute consumption quantities and expenditures, and to record production expenditures and changes in the debt or credit positions of the household (Singh et al., 1985). In principle, the transaction module records all market transactions of households, including purchases, sales, gifts, credit, and other market transactions with recall of about four-week intervals (Lim and Townsend, 1998).[4] The interview on this schedule was continued every month in the first week during the period 1975/76 (crop year from July 1975 to June 1976) to 1984/85 in three Indian villages, namely Aurepalle, Shirapur, and Kanzara.[5] All the cash and kind transactions after the previous interview were recorded in cash value either as cash inflow or as cash outflow, which make it possible to calculate monthly income, consumption, and changes in different components of the household asset.[6] Appendix 1 provides detailed information on how variables on monthly asset changes have been created using the transaction module.

As an extension, we have also explored the ICRISAT Village Dynamics in South Asia data from July 2009 to June 2012 with focus on the same three villages for comparative purposes. The

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[3] Although the ICRISAT data set itself has been widely used in the literature, few studies have used the original information found in the transaction module.

[4] Lim and Townsend (1998) describe in detail the structure of the transaction module and the way of constructing the monthly data on income, consumption, and asset change. We closely follow their methods and aggregate them to the seasonal data.

[5] In the other seven villages where the survey was carried out, transaction data were collected for only three or four years for the selected timeframe.

[6] There have been some discussions as to whether the data on consumption (own consumption of home production in particular) and grain stock are correctly recorded. Ravallion and Chaudhuri (1997) – based on the technical details given by Gautam (1991) - note a systematic underreporting problem in the ICRISAT data on own consumption of crop outputs produced at home. They argue that Townsend (1994) overestimates the degree of risk sharing in the village mainly due to the measurement-error problem. We have corrected the transaction data following Gautam in retrieving the cash and asset balances using the transaction data.

survey design of the new waves is very similar to the older one. We also match monthly rainfall data obtained from the Indian Meteorological Department to the survey data at the district level. The new dataset includes 90 households from Aurepalle, 89 households from Shirapur, and 62 households from Kanzara. The dataset is fairly balanced across different months.[7]

Due to minor differences in survey questionnaires and the difficulty in tracking households between old and new datasets, we opt not to pool all the data. The apparent drawback of using this dataset is that the crop inventory is recorded on an annual basis only and cultivation output data are collected on a seasonal basis. So it is not feasible to accurately recover monthly information on grain-stocks.

3. The Specification and the Empirical Results

Firstly, we compare the coefficient of variation (CV) of monthly consumption with the CV of monthly income in each year. Table 1 shows the results in four different landholding classes: the landless, small farmers, medium-sized farmers, and large farmers. For all the landholding classes, the CV of monthly consumption is significantly lower than that of monthly income at a 1 percent level, which implies that households smooth consumption during a single crop year. However, Table 1 also suggests that the extent to which households stabilize their consumption varies across different landholding classes. Although the average CVs of income of large and medium farmers are relatively higher (about 170 percent) and those of small farmers and the landless are lower (about 100 percent), the average CVs of consumption are almost the same across different landholding classes (about 50 percent). We also construct the smoothing ratios (SR) defined as $SR=1 - CV_{Consumption} / CV_{Income}$ where SR of 1 (or 0) corresponds to complete consumption smoothing (or no consumption smoothing) (Carter and Lybbert, 2012). The results which are

[7] For this analysis based on the new data, we focus only on monthly changes.

shown in the last column indicate that SR varies across different landholding classes – with SR the highest for medium-sized farmers (0.71) and the lowest for small farmers (0.52), although due to wide confidence intervals, the differences across different landholding classes are not statistically identified. Overall, our result is consistent with that of Townsend (1994) who shows that variation in consumption is surprisingly lower than variation in income based on the annual data of the Indian ICRISAT survey.

(Table 1 to be inserted)

Then, an empirical question arises: how well did households smooth consumption across months within a single crop year? Following Paxson (1992) and Fafchamps et al. (1998), we try to capture savings as a function of both permanent and transitory component of income.

$$S_{it} = \alpha_0 + Y_{it}^P\,\alpha_1 + Y_{it}^T\,\alpha_2 + VAR_{it}\alpha_3 + W_{it}\alpha_4 + \varepsilon_{it} \qquad (1)$$

where S_{it} is savings in various forms, Y_{it}^P is permanent income, *i.e.*, the portion of income that is constant over time, and Y_{it}^T is transitory income. *i* and *t* denote household and time (or year-month, t=1 for July 1976, t=2 for August 1976, … , t=84 for June 1983) respectively.[8] VAR_{it} (variance of income) and W_{it} (household characteristics) are assumed to be factors which affect the level of savings. If household savings behavior can be described appropriately by the life-cycle/ permanent income hypothesis, then $\alpha_1$would be 0; that is, permanent income does not affect the level of savings.

A crucial empirical question would be to identify the permanent and transitory components of household income. The studies on Indian households, such as those of Bhalla (1979, 1980) and Wolpin (1982), identify permanent income by the instrumental variables which are correlated only with the permanent component and compute transitory income as the rest of household income.

[8] A subscript denoting village, *v*, is omitted for simplicity (except for the rainfall variables).

One problem with this approach is that it is difficult to distinguish transitory component from measurement error. Paxson's (1992) study of rice farmers in Thailand isolates the transitory components of income which are exogenous by directly estimating the effects of transitory rainfall variation on crop income. We closely follow Paxson's estimation strategy by using the rainfall data to identify the transitory component.

The permanent component is determined by household characteristics and regional dummies, both of which affect long-term income-earning abilities of households. Permanent income is characterized as;

$$Y_{it}^{P} = \beta_t^{P} + \beta_v + X_{it}^{P}\beta_1 + \varepsilon_{it}^{P} \quad (2)$$

β_v is a village fixed effect and X_{it}^{P} is a set of household characteristics. ε_{it}^{P} is the error component. Transitory income is;

$$Y_{it}^{T} = \beta_t^{T} + R_t^{T}\beta_2 + L_{it}\otimes R_t^{T}\beta_3 + \varepsilon^{T}{}_{it} \quad (3)$$

where β_t^{T} is seasonal dummy variables, R_{vt}^{T} is a vector of village specific shocks, namely, rainfall shocks. L_{it} is the household landholding, which is interacted with a set of rainfall variables to take account of the fact that the rainfall shock affects households differently according to the size of their land. Combining the equations (2) and (3), we can describe the income equation as:

$$Y_{it} = \beta_t + R_{vt}^{T}\beta_2 + L_{it}\otimes R_t^{T}\beta_3 + \beta_v + X_{it}^{P}\beta_1 + \gamma_i + \varepsilon_{it} \quad (4)$$

Through the estimation of income equation (4) as in Paxson, we can decompose total household income into permanent and transitory components. γ_i is household fixed effects, that is, the unobserved characteristics which may be added to the permanent component. The predicted permanent and transitory incomes are then denoted by:

$$\hat{Y}_{it}^{P} = \hat{\beta}_v + X_{it}^{P}\hat{\beta}_1 + \hat{\gamma}_{iv} \quad (2)'$$

$$= \hat{Y}_{it} - \hat{Y}_{it}^{T}$$

$$\hat{Y}_{it}^{T} = \hat{\beta}_t^{T} + R_t^{T}\hat{\beta}_2 + L_{it} \otimes R_t^{T}\hat{\beta}_3 \qquad (3)'$$

Empirically, we first draw upon the two-step procedure in which income equation is estimated in the first step and savings equation for the change of each asset in the second.

In the present study, we use lagged deviations from the mean of village-level monthly rainfall in the ICRISAT data following the specification of Paxson (1992) and Fafchamps et al. (1998) based on the rainfall data to identify the transitory component. More specifically, we have defined rainfall variables in such a way that the seasonal pattern of rainfalls and their temporary shocks are captured at the same time. We have grouped lags of rainfall variables into three groups: the sum of the current rainfall and the first, the second and the third lags (R_1), that of the fourth to the seventh lags (R_2) and that of the eighth to the eleventh lags (R_3).[9] Monthly dummy variables, which express the deterministic seasonal patterns within a single crop year, are also included in the transitory factors.

The factors which determine permanent income include village dummies, sex/age/education variables, and the dummy variables on caste. To capture the combined effects of sex, age, and education on the permanent component of income, we generate count variables for the whole sample to capture the effects of the fifteen groups by sex, age group, and educational status (e.g. number of people aged 0 to 5, or number of males with primary education aged between 18 and 64). Owned land as well as a share of the irrigated area in owned land is added as permanent factors.

[9] Here the issues are whether our rainfall variables are justifiable and whether they are robust to other definitions. First, no single definition of rainfall variables can be considered ideal as it is difficult to match the past rainfall trends with the income on monthly basis given the seasonality of agricultural production. Our definition is admittedly arbitrary in terms of grouping of lags, but it would capture a part of the lagged effects of rainfalls on household income. We have tried a few other definitions (e.g. different groupings or number of lags) as robustness checks and have obtained broadly similar results. The final choice of lags or grouping has been guided by statistical significance of rainfall variables.

One of the problems with the above estimation based on the monthly data is that it does not take explicit account of the seasonal nature of agriculture in formulating an income equation. Therefore, we apply a slightly different specification to estimate the crop-income equation, drawing upon Jacoby and Skoufias (1998) and Carter and Lybbert (2012).

In the estimation of seasonal income, we model crop income in the peak season as a function of 1) the household characteristics (sex/age/education variables, castes) in the agricultural slack season, 2) the variables on production capitals and inputs in the slack season, 3) village dummies, 4) the rainfall in the slack season and its cross term with owned land in the slack season, and 5) the rainfall in the peak season (October to December) and its cross term with owned land in the slack season (June to September). In the first stage, the profit in the peak season is estimated.

$$\pi_{it} = \beta_1 + X'_{it-1}\beta_2 + \beta_3 R^s_{vt-1} + (L_{it-1} \otimes R^s_{vt-1})'\beta_4 + \beta_5 R^p_{vt} + \left(L_{it-1} \otimes R^p_{vt}\right)'\beta_6 + \vartheta_i + e_{it}$$

(5)

where X'_{ist} is farm/household characteristics and information sets available at the slack season; R^s_{vt-1} is rainfall before planting (June-Sept) (capturing transitory shocks in the slack season); and R^p_{vt} is rainfall after planting prior to harvesting (Oct-Dec) (capturing shocks in the corresponding period).[10] t stands for crop year (t=2 for 1977/78; t=3 for 1978/79, … , t=7 for 1982/83). L_{it} stands for the household land holding. Rainfall variables are interacted with the current owned land to take into account the fact that rainfall affects the households differently according to the size of land. Transitory and permanent crop income can be written as:

$$\hat{\pi}^T_{it} = \hat{\beta}_3 R^s_{vt-1} + (L_{it} \otimes R^s_{vt-1})'\hat{\beta}_4 + \hat{\beta}_5 R^P_{vt} + (L_{it} \otimes R^P_{vt})'\hat{\beta}_6$$

$$\hat{\pi}^P_{it} = \hat{\beta}_1 + X'_{it-1}\hat{\beta}_2 + \hat{\vartheta}_i$$

[10] In the case where we estimate seasonal income, rainfall variables are defined to capture the season-specific transitory rainfall shocks. The results are robust to other definitions of rainfall variables.

$= \hat{\pi}_{it} - \hat{\pi}_{it}^{T}$

In the second stage, the household savings response to transitory crop-income shocks and permanent incomes is estimated.

$$\boldsymbol{Savings}_{\,it} = \boldsymbol{\sigma} + \boldsymbol{\gamma}^{\boldsymbol{T}} \widehat{\boldsymbol{\pi}}_{it}^{\boldsymbol{T}} + \boldsymbol{\gamma}^{\boldsymbol{P}} \widehat{\boldsymbol{\pi}}_{it}^{\boldsymbol{P}} + \boldsymbol{\mu}_{i} + \boldsymbol{e}_{it} \qquad (6)$$

Savings in this case are defined as the net increase in a variety of assets during the peak period. In order to capture the seasonality in agriculture, we use the household crop income in the peak season, rather than the total household income. If γ^{T} is positive and significant, we can conclude that households save when the transitory crop income (both expected and unexpected transitory income) in the peak season is high, and dissave when transitory income is low.

Table 2 shows the GLS estimates of the reduced forms of monthly and seasonal income estimations specified by the above equations. The estimation results associated with rainfall show that 1) rainfall during the period from the eleventh lagged month to the eighth lagged month has a positive impact on monthly income and, 2) the cross terms of owned land and rainfall during the period from the seventh lagged month to the fourth lagged month (or from the third lagged month to the current month) have positive and significant effects on monthly income. The latter implies that the income of households with larger areas of land is more strongly affected by rainfalls. In Case B where crop income in the peak season is applied, we find that 1) the interaction term of owned land and rainfall during the slack season (June to September) has a positive and significant effect on crop income in the peak season and, 2) rainfall during the peak season (October to December) has a positive impact on crop income.

(Table 2 to be inserted)

Panel A of Table 3 includes the summary results of two-step GLS estimates of monthly and seasonal savings in various forms. Each form of savings is estimated separately. Cases (a), (b), (c), (d), and (e), corresponding to the identity (the equation (1)), show the net increase in capital assets (production capital assets *plus* consumer durables), crop inventory, input inventory, financial assets (including credit), and cash holdings respectively. Saving or dissaving as a form of crop inventory is the most important device for households to buffer consumption. The second important device of consumption smoothing is currency, as Case (d) shows. As expected, currency is not saved from the increase in permanent income. In the case of capital assets (Case (a)) and financial assets (Case (d)), both transitory and permanent incomes have positive and significant coefficients. They are important not only as a device of consumption smoothing but also as a measure to save permanent income. Financial assets in Case (d) include financial savings, credit (in terms of lending *minus* borrowing), and gifts from others, although they consist mainly of credit. Consumption smoothing through village-level risk-sharing mechanism roughly corresponds to 'credit' in Case (d), considering the dominant role of informal borrowing and lending in the rural credit market. The fact that the coefficient of transitory income in Case (d) is not so large (0.10) implies that households smooth consumption through intertemporal savings, rather than through risk sharing among different households within the village.

(Table 3 to be inserted)

Cases (f) and (g) show that consumption is considerably smoothed out by savings, physical savings in particular. These results correspond to those in Table 1. Case (h) suggests that livestock is not used as a buffer stock, contrary to the results shown by Rosenzweig and Wolpin (1993). We decompose the net change of capital assets (Case (a)) into the net change in production capital (Case (i)) and the net change of consumer durables (Case (j)). In monthly analysis, consumer durables seem more important than production capital as buffer stocks.

Panel B of Table 3 shows the case of GLS estimates of a savings equation in which the seasonal data are used. Cash holdings (Case (e)) are the most important factor to buffer consumption because transitory income affects positively and significantly the net change in cash holdings. Crop inventory seems to be used as a buffer stock, though the coefficient associated with transitory income is not significant. Financial assets and capital assets do not serve as buffer stock at all. Rather do they increase consumption fluctuations, because transitory income has negative coefficients. Case (f) implies that consumption is significantly smoothed out across different seasons but the physical savings (Case (g)) are less important. The buffer-stock role of consumer durables is not clearly observed.

If the results based on the monthly data are decomposed by the landholding classes, it is found that all the landholding classes smooth consumption well, relying upon physical assets. [11] For all the landholding classes, crop inventory plays an important part for consumption smoothing, while capital assets are used only for large farmers and the landless. Only for large farmers do cash holdings and savings/dissavings of livestock serve as buffer stock. For the landless, on the other hand, production capital is one of the main devises to smooth consumption.

4. Extensions

The methodology in the last section has the following two limitations. First, as the savings equation in the second step is estimated for each form of household asset separately, the coefficient of transitory income does not reflect the relative importance of different household assets. To see the household response of portfolio adjustment to income shocks more clearly, it is necessary to estimate savings equations simultaneously. Second, some categories of the savings in the second step are likely to affect the income equation in the first step. In particular, the changes in

[11] Details will be provided on request.

production capital, input inventory, and financial assets (credit in particular) might affect the transitory income. In this section, therefore, we estimate the system of equations as an extension of the methodology put forward by Paxson (1992).

The following system of equations is estimated by three-stage least squares estimation.

$$\boldsymbol{Y_{it} = \beta_t^T + R_{vt}^T\beta_1 + L_{it}\otimes R_{vt}^T\beta_2 + \Delta P_{it}\beta_3 + \Delta I_{it}\beta_4 + \Delta F_{it}\beta_5 + \beta_6 V_v + \gamma_i + \varepsilon_{it}} \quad (7)$$

where Y_{it} is monthly income, β_t^T is a set of dummies to capture the seasonal fluctuations, R_{vt}^T is a vector of lagged rainfall shocks. L_{it} is the stock of household landholding at the beginning of the crop year to be interacted with landholding. ΔP_{it}, ΔI_{it}, and ΔF_{it} are the net monthly changes in production capital, input inventory, and financial assets respectively. V_v is a village-level dummy variable. γ_i is the household fixed effects. Because we focus on the temporary shocks in Y_{it}, we subsume permanent factors under γ_i.

$$\boldsymbol{\Delta K_{it} = \alpha_{k0} + Y_{it}\alpha_{k1} + R_{vt}^T\alpha_{k2} + W_{it}\alpha_{k3} + \alpha_{k4}V_v + \alpha_{k5}k_{it-1} + e_{it}^k} \quad (8)$$

where ΔK_{it} is the net monthly change in capital asset.

W_{it} is the household characteristics which are assumed to affect savings. Asset changes are assumed to be influenced by an endogenous temporary income shock, Y_{it}, and rainfall shocks. k_{it-1} is the annual stock of production capital at the last crop year which identifies the equation.[12]

The other savings equations are specified similarly.

$$\boldsymbol{\Delta D_{it} = \alpha_{d0} + Y_{it}\alpha_{d1} + R_{vt}^T\alpha_{d2} + W_{it}\alpha_{d3} + \alpha_{d4}V_v + \alpha_{d5}d_{it-1} + e_{it}^d} \quad (9)$$

$$\boldsymbol{\Delta S_{it} = \alpha_{s0} + Y_{it}\alpha_{s1} + R_{vt}^T\alpha_{s2} + W_{it}\alpha_{s3} + \alpha_{s4}V_v + \alpha_{s5}s_{it-1} + e_{it}^s} \quad (10)$$

$$\Delta I_{it} = \alpha_{I0} + Y_{it}\alpha_{I1} + R_{vt}^T\alpha_{I2} + W_{it}\alpha_{I3} + \alpha_{I4}V_v + \alpha_{I5}L_{it-1} + e_{it}^I \quad (11)$$

$$\Delta F_{it} = \alpha_{f0} + Y_{it}\alpha_{f1} + R_{vt}^T\alpha_{f2} + W_{it}\alpha_{f3} + \alpha_{f4}V_v + \alpha_{f5}f_{it-1} + e_{it}^f \quad (12)$$

$$\Delta M_{it} = \alpha_{m0} + Y_{it}\alpha_{m1} + R_{vt}^T\alpha_{m2} + W_{it}\alpha_{m3} + \alpha_{m4}V_v + \alpha_{m5}n_{it-1} + e_{it}^{fn} \quad (13)$$

[12] In the asset equations, household fixed effects are not included (while a number of household characteristics are included) to make the conversion of estimations achievable.

where $\Delta D_{it,}$ $\Delta S_{it,}$ $\Delta I_{it,}$ $\Delta F_{it,}$ and ΔM_{it} are the net increases in consumer durables, crop inventory, input inventory, financial assets, and cash holdings respectively. d_{it-1}, s_{it-1}, L_{it-1}, f_{it-1}, and n_{it-1} are the annual stock of consumer durables, grain stock, owned land, net borrowings, and net worth (*i.e.*, real assets *minus* liabilities) respectively. The system of equations of (7) - (13) is first estimated for monthly data. The same specification is then applied to seasonal data.

Here, the important question is the extent to which the system of simultaneous equations captures the simultaneity in household decision making of portfolio adjustment where households take into account their holding of a particular asset, when making adjustment in another asset. Ideally, the interactions between different household assets should be explicitly modeled, but the data limitations do not allow us to disentangle the complex causal relationships among different assets in terms of the households' portfolio adjustment and their underlying decision-making. First, while our system of simultaneous equations could capture interactions between the income equation and the asset equations, the cross-interactions across asset-change equations are not *explicitly* modeled as each asset-change is only identified by its lags, while they are *indirectly* linked through income changes, as contemporaneous interactions among error terms are allowed.[13] Second, our approach is inherently limited - as in most of other econometric approaches - in a sense that the *ex ante* portfolio adjustment decision is captured only by the past data. While households decide in advance whether they want to save or dissave a certain asset component, the actual savings reflected in the data may be different because of a lot of constraints for savings (e.g. the market of livestock, price changes). Given these limitations, our regression result is at best a summary of the household portfolio adjustment behavior based on the *ex post* data. To supplement our approach of using the system of simultaneous equations, we carry out a cluster analysis to

[13] We could use, for example, lagged values of asset changes as instruments, but this would make the system too complex to be estimated. We do not have valid external instruments to identify each asset-change equations due to the data limitations.

understand, albeit descriptively, the different risk coping responses and observe the households' characteristics based on their asset dissaving patterns in the wake of income shocks.

Table 4 shows the results of the income equation for monthly data (Case A) and seasonal data (Case B). The net increase in production capital and input inventory has positive and significant impacts on both the monthly and the seasonal income. Monthly income is positively affected by the net change in financial assets, including credit. The coefficient estimate of financial assets is not significant for seasonal crop income (Case B).

(Table 4 to be inserted)

Table 5 shows the results of asset change estimations for monthly data (Panel A) and seasonal data (Panel B). The overall results are not so different from those in Table 3. In Panel A, crop inventory is the most important device in smoothing consumption. The coefficients associated with financial assets have become larger than those shown in Table 3, while the relative importance of cash holdings has decreased. Consumer durables are still important as buffer stock, while production capital and input inventory are not.

(Table 5 to be inserted)

It is evident from panel B of Table 4 that crop inventory and cash holdings are used as buffer stock for seasonal fluctuation in crop income. In addition, production capital, consumer durables, and financial assets play a minor role in buffering consumption. Transitory income has a positive and significant impact on the input inventory, which suggests that farmers adjust the timing of purchasing and selling so that consumption smoothing can be achieved.

Comparisons of Panel A and Panel B are insightful in inferring some features of household portfolio-adjustment behavior. While financial assets (including credit) are one of the important devices for consumption smoothing in the case where monthly data are used, they are not important in the case of seasonal data. It is rather the case that currency plays a key role in mitigating the seasonal fluctuation. Whilst consumer durables are used as buffer stocks for monthly crop shocks, it is production capital that appears to mitigate seasonal crop shocks. This implies that the relatively productive assets, which are closely associated with crop production, tend to be used as buffer stocks to mitigate the seasonal crop shocks.

As we have discussed, our approach using the system of simultaneous equations does not fully capture the interactions between different household assets. Accordingly, we have carried out a cluster analysis to examine the household portfolio effects by closely following Kusunose and Lybbert (2014) (see Appendix 2 for details). The results of this analysis are broadly consistent with those of econometric analyses in Tables 3 and 5. However, cluster analysis does not provide any clear evidence in support of interactive portfolio effects using more than one type of asset to cope with a monthly income shock. In other words, dissaving of multiple assets does not appear to be more effective than that of a single asset for coping with an income shock that occurs in a particular month. However, as Kusunose and Lybbert note, cluster analysis is descriptive in nature and our results based on this approach should be interpreted with caution.

Furthermore, we have re-estimated the results of Table 5 village-wise and based on the different landholding classes. Figure 1 comparatively shows the coefficient estimates and their confidence intervals in error bars for the different landholding classes and villages using monthly data. For all landholding classes, crop inventory is the most important device for buffering consumption, as its coefficient estimate is the largest and statistically significant for all categories.

For large farmers, apart from crop inventory, cash holdings and financial assets - both of which are statistically significant - are used as buffer stock. For medium farmers, while the role of the crop inventory is still prominent, financial assets are also important, having a positive and significant estimate. Small farmers seem to have various forms of smoothing consumption, namely crop inventory, cash, and production capitals, all of which are statistically significant. For the landless, production capital supplements the buffer-stock role of the crop inventory. The role of cash holdings as a buffer stock is not evident in the case of the landless households, suggesting that they may not have enough cash that can be used to cope with income shocks.

(Figure 1 to be inserted)

We also disaggregate the results by villages. In Kanzara where the average household income is high, the importance of the crop inventory as buffer stock is lower - though it is statistically significant - than in the other two villages. In addition, cash holdings and consumer durables also serve as buffer stocks as both respond positively to income shocks. In Shirapur and Aurepalle, the role of the crop inventory is dominant, but financial assets are also important. Cash holdings play no role in smoothing consumption in Shirapur and Aurepalle in Figure 1.

It is difficult to find any common pattern across different landholding classes or villages. However, it is noteworthy that consumption smoothing is achieved through savings or dissavings of several kinds of assets and not by a single asset over a long period.[14] Another important implication derived from our results concerns the relative importance of the risk-sharing mechanism among households and the autarky of intertemporal risk-coping mechanism. Among a variety of portfolio choices, it can be reasonably assumed that a majority of 'financial assets'

[14] This may not be evident in the results of the cluster analysis; because of this method's inability to capture sequential dissavings of multiple assets over time. It is likely that households sell on asset at one point in time, but several assets over a longer period.

(which include informal borrowing and lending and gifts) are classified into the former and the rest (*i.e.*, sum of production capital, consumer durables, crop inventory, input inventory and cash holdings, and a part of financial assets, such as financial savings) is classified into the latter. As the coefficient of transitory income associated with financial assets is positive but not large, it is adequate to conclude that the intertemporal savings (which draw upon crop inventory, capital assets, or cash holdings) are more fundamental to risk coping mechanisms than they are to risk sharing (such as lending or borrowing between households in the village).

5. Results based on more recent ICRISAT data

Using a more recent ICRISAT dataset between 2009 and 2012, we investigate the behavioral responses of households in the same regions of rural India (Aurepalle, Shirapur, and Kanzara). The variables in this section are slightly altered according to data availability and survey design of the new data. We first estimate the income equation given in equation (4) and then decompose income into transitory and permanent components in the same fashion as equations (2)' and (3)'. In this section, we focus on the results based on monthly fluctuations. Table 6 shows the results of the reduced form income equation based on monthly data. It is found that the coefficient estimate of rainfall is positive and significant, while the interaction of rainfall and area of owned land is negative and significant. The latter suggests that larger landholders tend to be more severely affected by rainfall shocks. This result is consistent with the coefficient estimates of the third lag of rainfall and its interaction with land based on old ICRISAT data (Case A of Table 2).

(Table 6 to be inserted)

Based on this decomposition of income into permanent and transitory components, we estimate household response of the following assets to transitory shocks: savings (total), net loan balance, livestock, consumer durables, and machinery as reported in Table 7. The selection of these categories was guided by the availability of the comprehensive asset data in the new ICRISAT data. To facilitate comparisons between Table 3 and Table 7, the same letters are used in upper case for the asset categories (e.g. Case (F) in Table 7 corresponds to Case (f) in Table 3).[15] That is, Cases (A), (F), (H), (I), and (J) show the net increases of capital assets, saving (total), livestock, production capital, and consumer durables respectively. Case (D) shows the net decrease of loan balance. As previously noted, the monthly fluctuations of crop inventory could not be retrieved from the new dataset.

(Table 7 to be inserted)

Here we restrict our attention to the coefficient estimates of transitory income for each case, because they are likely to capture the households' asset responses to income shocks. In Case (F) of Table 7 in which total savings is a dependent variable, the coefficient estimate of transitory income is 0.93 - which is close to 1 - and highly significant, which suggests that households smooth their consumption well (Paxson, 1992; Carter and Lybbert, 2012) [16]. This is close to the coefficient estimate of transitory income for total savings (0.99) in Case (f) of Table 3 based on the old ICRISAT data. Consistent with our findings from the 1976-1983 dataset in Table 3, livestock (Case (H)) does not have a vital role as buffer stock, nor do consumer durables (Case (J)), production capital (Case (I)), or capital assets (Case (A)), have a vital role as buffer stock. Coefficient estimate is close to 0 in both cases. Loan balance (Case (D)), however, appears to be

[15] It is noted that only part of the asset categories are available in the new ICRISAT data.
[16] Given that Saving=Income – Consumption, a decrease in income by, say, 1000 Rupees is offset by a decrease in saving by as much, keeping consumption smooth.

the most responsive to transitory income with a positive and significant coefficient. The coefficient estimate is 0.45, the largest among all the cases except Total Savings. That is, if income increases by 1000 Rupees, net loan balance tends to decrease by 450 Rupees. This is similar to Case (d) of Table 3 based on the old dataset in which the coefficient of financial assets (including credit) is positive and significant, though much smaller than in Case (D) of Table 7. This implies that the relative importance of credit as a means of risk coping increased in more recent years. Production capital or consumer durables is statistically insignificant (Cases (I) and (J)) as in Cases (i) and (j) of Table 3. It is difficult to carry out further extensions based on the new dataset, e.g., to estimate the system of equations, because the data for only a part of household assets are available. However, the results based on the new ICRISAT panel data are broadly consistent with our main findings based on the old ICRISAT data.

6. Conclusion

One of the most important implications derived from the panel data estimation is that not only the level but also the diversification of household assets is important for smoothing consumption. The results of our analysis yield several crucial conclusions.

First, in the case where monthly data are used, savings as changes of major household assets have a role in buffering consumption. In particular, change in crop inventory, currency capital assets (consumer durables in particular), and financial assets (credit in particular) are important for consumption smoothing. We confirm that when permanent income increases, a household saves crops, production capital and financial assets, rather than currency or livestock. In general, livestock plays little part in smoothing the fluctuation of household consumption within a single year. These results derived from monthly data are not so different in the case where crop income in the peak season is estimated, except that cash holdings play a more important role as buffer stock in the latter. These results are based on the ICRISAT panel data for the period 1976-1983, but we have examined the robustness of our results using the new ICRISAT monthly panel data for the period 2009-2012. We have found using the new dataset that financial assets, rather than livestock, play a more important when households respond to transitory income shocks. This is consistent with the main findings based on the old dataset.

Second, the importance of portfolio adjustment and the consumption-smoothing mechanism are also confirmed by the system of equations in which portfolio adjustment and production decisions are simultaneously estimated. This result is important, not just because the majority of the past studies on consumption smoothing or savings treat income as exogenous, but also because the empirical studies on savings do not normally pay explicit attention to the aspect of portfolio adjustment.

Third, decomposition by the landholding class or village suggests that consumption smoothing is achieved through savings or dissavings of several kinds of assets and not by a single asset. The pattern of portfolio adjustment, however, differs among different landholding classes. While large farmers rely on a number of assets, including crop inventory, currency, financial assets, and capital assets in smoothing consumption, small and medium farmers use the crop inventory as a main device for buffering their consumption. The landless households smooth consumption through an adjustment of multiple assets, such as grain stock, financial assets, production capital and consumer durables. However, our cluster analysis does not provide any clear evidence in support of interactive portfolio effects (*i.e.* dissaving more than one type of asset *simultaneously*) to cope with a monthly income shock. The household is thus likely to use a single asset at one time, or in a particular month, to cope with a sudden income shock, but more than one type of assets over a long period.

Fourth, it appears that intertemporal savings, which draw upon crop inventory, capital assets, or currency, are more important as a measure of risk coping than risk sharing, through lending or borrowing across different households. On one hand, these results are in sharp contrast with the analysis of Townsend (1994) which shows that consumption is smoothed out by the risk-sharing arrangement within the villages on the basis of the annual ICRISAT data. On the other hand, our discussion is in line with Ravallion and Chaudhuri (1997), a critique against Townsend's seminal paper. Our paper suggests that Townsend's results, which support the 'risk-sharing' hypothesis, can be largely affected by the autarkic 'intertemporal savings' of each household which can follow a common trend among different households within the villages.

It is often argued that the poor are constrained by lack of access to credit or savings, but the present study suggests that once we track the record of all the household assets, even the landless households cope with income shocks quite well by adjusting a variety of their assets over time. Any policy interventions to address the vulnerability of the poor in rural areas should consider this aspect. Future studies should investigate whether the pattern of the portfolio adjustment is similar, or whether the portfolio adjustment (e.g. dissaving of production capital) has any implications for poverty dynamics.

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Figure 1 Household Reaction to Transitory Crop Income Shocks: Decomposition by landholding class and village (based on 3SLS shown in Table 5): Monthly Data

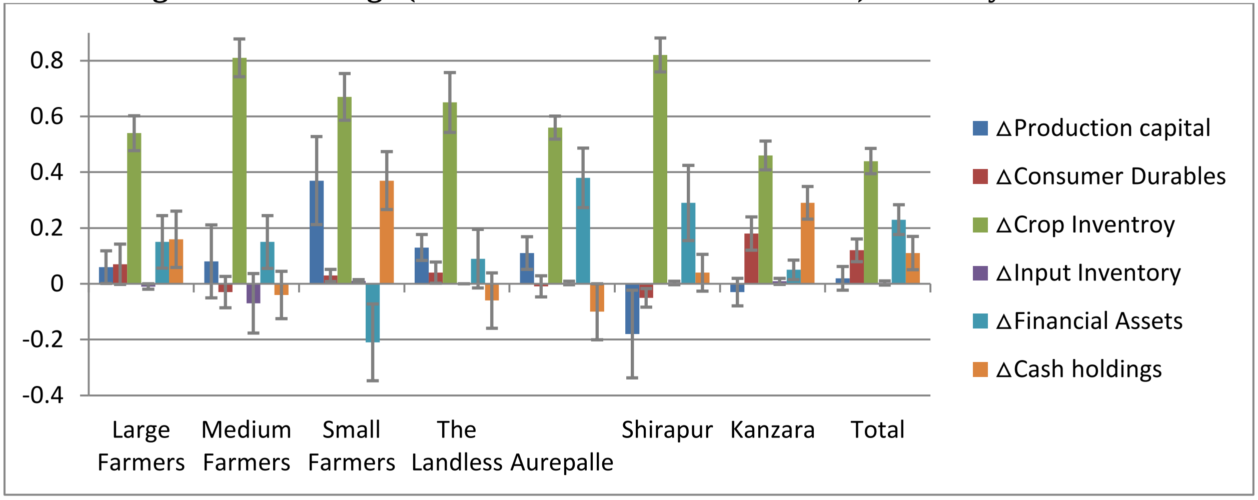

Table 1 The Comparison of CV (Coefficient of Variation) of Monthly Income and CV of Monthly Consumption in rural India, 1976-84

CV for each year, 1976-84

	Average CV of Income (a)	Average CV of Consump-tion (b)	Average reduction	No. of Observations	t test (a)-(b)		Smoothing Ratios 1-(b)/(a)	Confidence Interval (95%) For Smoothing Ratios	
Landless	100.8	43.8	57	205	2.4	**	0.57	0.104	1.027
Small farmer	103.1	49.3	53.9	243	8.16	**	0.52	0.397	0.648
Medium-Sized	169.8	49.4	120.3	240	5.32	**	0.71	0.447	0.969
Large farmer	167.4	58.6	108.8	243	15.22	**	0.65	0.566	0.734
Total	136.6	50.5	86	931	10.4	**	0.63	0.511	0.748

**= significant at 1% level. *= significant at 5% level. +=significant at 10% level.

Table 2. Estimations of the Reduced Form Income Equations based on the ICRISAT data from 1976 to 1983 (summary results)

	Case A (Monthly Income)	Case B (Crop Income in Peak Season)

Variable	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
Transitory Factors				
Rainfall variables:[1)]				
(R_1- mean of R_1) :$R_1 = r_0 + r_{-1} + r_{-2} + r_{-3}$	-2.22	(-2.35)*	-------------------	
where r_{-t} is the *t-th lagged monthly rainfall*				
(R_1- mean of R_1)*(Owned Land)	0.66	(5.56)**	-------------------	
(R_2- mean of R_2) :$R_2 = r_{-4} + r_{-5} + r_{-6} + r_{-7}$	-3.37	(-3.60)**	-------------------	
(R_2- mean of R_2)*(Owned Land)	0.81	(6.87)**	-------------------	
(R_3- mean of R_3) :$R_3 = r_{-8} + r_{-9} + r_{-10} + r_{-11}$	2.35	(2.53)*	-------------------	
(R_3- mean of R_3)*(Owned Land)	-0.94	(-8.16)**	-------------------	
(R_4- mean of R_4) :R_4 =Rainfall in June-Sept	------------------		-10.76	(-2.11)*
(R_4- mean of R_4)^2	------------------		0.04	(1.77)†
(R_4- mean of R_4)*(Owned Land)	------------------		0.002	(2.15)*
(R_5- mean of R_5) :R_5 =Rainfall in Oct-Dec	------------------		23.80	(1.80)†
(R_5- mean of R_5)^2	------------------		-0.21	(-1.32)
(R_5- mean of R_5)*(Owned Land)	------------------		0.003	(0.40)
Seasonal Dummies: [3)]				
Whether July or not	85.86	(0.99)	---------------	
Whether Aug or not	208.00	(2.38)*	---------------	
Whether Sept or not	340.37	(3.84)**	---------------	
Whether Oct or not	889.42	(10.06)**	---------------	
Whether Nov or not	831.07	(8.98)**	---------------	
Whether Dec or not	764.12	(8.30)**	---------------	
Whether Jan or not	398.63	(4.38)**	---------------	
Whether Feb or not	558.59	(6.37)**	---------------	
Whether Mar or not	724.17	(8.23)**	---------------	
Whether Apr or not	556.82	(6.42)**	---------------	
Whether May or not	204.59	(2.38)*	---------------	
Permanent Factors				
Village dummies: [3)]				
Whether Shirapur or not	-144.57	(-1.79)†	-30.2.09	(-3.17)**
Whether Aurepalle or not	-194.36	(-2.42)*	-4010.96	(-4.55)**
Sex/ age/ education variables:				
Number of people aged 0-5	-7.30	(-0.32)	-122.26	(0.48)
Number of males aged 6-11	53.90	(1.65)†	9.26	(0.03)
Number of females aged 6-11	25.48	(0.70)	42.75	(0.11)
Number of males aged 12-17	-59.23	(-1.63)	749.12	(1.94)*
Number of females aged 12-17	47.56	(1.33)	-352.16	(-0.90)
Number of males aged 18-64				
Illiterate	41.08	(1.00)	395.84	(0.84)
Primary school or less	114.36	(2.19)*	72.55	(0.13)
Secondary school	116.68	(2.02)*	84.82	(0.13)
Post secondary school	102.79	(2.00)*	458.13	(0.89)
Number of females aged 18-64				
Illiterate	84.63	(2.08)*	-1010.68	(-2.15)*
Primary school or less	23.61	(0.35)	777.29	(1.04)
Secondary school	116.68	(2.02)*	-303.69	(-0.44)

Post-secondary school	102.79 (2.00)*	-1299.04 (-1.21)
Number of males aged 65 or more	-158.81 (-1.97)*	82.12 (0.10)
Number of females aged 65 or more	-61.47 (-0.60)	465.16 (0.61)
Variable on the caste:[3]		
whether high caste or not	-59.85 (-0.63)	460.50 (0.42)
whether mid-high caste or not	158.34 (1.80)†	1354.87 (1.51)
whether mid-low caste or not	4.17 (0.04)	1514.69 (1.47)
Owned Land (ha.)	23.93 (2.78)**	362.53 (4.69)**
Share of Owned Land which is Irrigated	773.79 (7.52)**	5465.59 (4.41)**
Stock of Livestock (Rs.)	0.08 (7.07)**	0.65 (5.73)**
Stock of Production Capital (Rs.)	0.02 (6.44)**	0.04 (1.05)
Input Spending in Slack Season (Rs.)	------------------	1.98 (1.99)**
Constant	-322.61(-2.54)**	1679.3 (1.49)
Number of Observations	7703	504

Note: [1] Square takes negative value when the deviation is negative. [2] Number in parentheses is *t* ratio. **= significant at 1% level. *= significant at 5% level. †= significant at 10% level. [3] Dummy variable.

Table 3 Two-step Random-effects GLS Estimates of Savings Equations

Panel A: Based on Monthly Data

Dependent Variable:	Case(a) △Capital Assets (-Σ△ K_{ijt} P_{ijtt})		Case(b) △Crop Inventory (-Σ△ $S_{ijt}P_{ijt}$)		Case(c) △Input Inventory (–Σ△ $I_{ijt}P_{ijt}$)		Case(d) △Financial Assets (-Σ△ $B_{ijt}P_{ijt}$) (including credit)		Case(e) △Cash holdings[2] (–△M_{jt})	
Explanatory Variable:	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
Transitory Income	**0.13**	**(4.09)****	**0.54**	**(11.42)****	**-0.02**	**(-4.70)****	**0.10**	**(2.52)****	**0.23**	**(5.78)****
Permanent Income	**0.11**	**(2.73)***	**0.56**	**(9.64)****	**-0.002**	**(-0.42)**	**0.09**	**(1.92)†**	**-0.02**	**(-0.37)**
Number of Observations	**7703**		**7703**		**7703**		**7703**		**7703**	
Dependent Variable:	**Case (f) Savings Total (Sum of Case a, b, c, d, & e)**		**Case (g) △Physical Savings (Sum of a & b)**		**Case (h) △Livestock [4]**		**Case (i) △Production Capital [4]**		**Case (j) △Consumer Durables [5]**	
Explanatory Variable:	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
Transitory Income	**0.99**	**(19.26)****	**0.67**	**(11.64)****	**0.01**	**(1.38)**	**-0.06**	**(-1.60)**	**0.19**	**(7.20)**
Permanent Income	**0.82**	**(10.94)****	**0.65**	**(8.45)****	**-0.06**	**(-4.95)****	**0.09**	**(1.95)**	**0.04**	**(1.03)**
Number of Observations	**7668**		**7703**		**7703**		**7703**		**7703**	

Panel B: Based on Seasonal Data

Dependent Variable:	Case(a) △Capital Assets (-Σ△ K_{ijt} P_{ijtt})		Case(b) △Crop Inventory (-Σ△ $S_{ijt}P_{ijt}$)		Case(c) △Input Inventory (–Σ△ $I_{ijt}P_{ijt}$)		Case(d) △Financial Assets (-Σ△ $B_{ijt}P_{ijt}$) (including credit)		Case(e) △Cash holdings[2] (–△M_{jt})	
Explanatory Variable:	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
Transitory Income	**-0.06**	**(-0.46)**	**0.42**	**(1.37)**	**0.03**	**(2.01)***	**-0.33**	**(-1.48)**	**0.88**	**(2.62)****
Permanent Income	**0.04**	**(1.02)**	**0.55**	**(7.66)****	**0.02**	**(4.27)****	**-0.03**	**(-0.60)**	**0.28**	**(3.12)****
Number of Observations	**504**		**504**		**504**		**504**		**504**	
Dependent Variable:	**Case (f) Savings Total (Sum of Case a, b, c, d, & e)**		**Case (g) △Physical Savings (Sum of a & b)**		**Case (h) △Livestock [4]**		**Case (i) △Production Capital [4]**		**Case (j) △Consumer Durables [5]**	
Explanatory Variable:	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
Transitory Income	**1.02**	**(2.94)****	**0.35**	**(1.01)**	**0.02**	**(0.37)**	**-0.17**	**(-1.13)**	**0.11**	**(1.30)**
Permanent Income	**0.79**	**(7.60)****	**0.57**	**(6.65)****	**-0.04**	**(-2.74)****	**0.02**	**(0.50)**	**0.02**	**(0.98)**
Number of Observations	**504**		**504**		**504**		**504**		**504**	

Note: [1]Number in parentheses is *t* ratio. **= significant at 1% level. *= significant at 5% level. †= significant at 10% level. [2] Both Production capital (Case (h)) and Consumer Durables (Case (i.)) are a part of Capital assets (Case (a)).[3] Livestock (Case (j)) is a part of production capital of financial assets (Case (d)).

Table 4 System of Equations (based on 3SLS for Monthly Data and Seasonal Data) Income Equation

	Case A (Monthly Income)		**Case B (Seasonal Crop Income)**	
Variable	Parameter Estimate	*t*-ratio	Parameter Estimate	*t*-ratio
Rainfall variables:[1)]				
(R_1- mean of R_1) :$R_1 = r_0 + r_{-1} + r_{-2} + r_{-3}$ where r_{-t} is the *t-th lagged monthly rainfall*	2.53	(2.21)*	-------------------	
(R_1- mean of R_1)*(Owned Land)	0.23	(1.77)†	-------------------	
(R_2- mean of R_2) :$R_2 = r_{-4} + r_{-5} + r_{-6} + r_{-7}$	-1.45	(-1.23)	-------------------	
(R_2- mean of R_2)*(Owned Land)	0.38	(3.98)**	-------------------	
(R_3- mean of R_3) :$R_3 = r_{-8} + r_{-9} + r_{-10} + r_{-11}$	-1.75	(-1.49)	-------------------	
(R_3- mean of R_3)*(Owned Land)	-0.49	(-5.08)**	-------------------	
(R_4- mean of R_4) :R_4 =Rainfall in June-Sept	------------------		9.49	(1.55)
(R_4- mean of R_4)^2	------------------		-0.016	(-0.73)
(R_4- mean of R_4)*(Owned Land)	------------------		-0.001	(-1.56)
(R_5- mean of R_5) :R_5 =Rainfall in Oct -Dec	------------------		9.01	(0.63)
(R_5- mean of R_5)^2	------------------		-0.03	(-0.19)
(R_5- mean of R_5)*(Owned Land)	------------------		0.006	(1.18)
Seasonal Dummies: [3)]				
Whether July or not	242.75	(2.27)*	---------------	
Whether Aug or not	214.87	(2.36)*	---------------	
Whether Sep or not	260.10	(3.07)**	---------------	
Whether Oct or not	384.10	(4.23)**	---------------	
Whether Nov or not	320.72	(3.54)**	---------------	
Whether Dec or not	254.76	(2.94)**	---------------	
Whether Jan or not	246.22	(2.54)**	---------------	
Whether Feb or not	314.29	(3.67)**	---------------	
Whether Mar or not	507.11	(5.28)**	---------------	
Whether Apr or not	364.00	(3.76)**	---------------	
Whether May or not	251.96	(3.27)**	---------------	
△ Production Capital	1.64	(8.41)**	1.80	(3.27)**
△ Input Inventory	6.82	(7.14)**	54.22	(6.71)**
△Financial Assets (including Credit)	3.08	(20.36)**	-0.52	(-1.49)
Constant	250.40	(2.72)**	3389.43	(6.30)
Number of Observations	7703		504	

Note: [1)] Square takes negative value when the deviation is negative. [2)]Number in parentheses is *t* ratio. **= significant at 1% level. *= significant at 5% level. †= significant at 10% level. [3)] Dummy variable.

Table 5 System of Equations (based on 3SLS for Monthly Data and Seasonal Data)
Asset Equations

Panel B: Based on Monthly Data

Dependent Variables:	**△Production Capital**	**△Consumer Durables**	**△Crop Inventory**	**△Input Inventory**	**△Financial Assets**	**△Cash holdings[2)]**
Explanatory Variable:	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)
Monthly Income (Transitory Income)	0.02 (0.92)	**0.12 (5.79)****	**0.44 (18.84)****	0.003 (0.83)	**0.23 (8.42)****	**0.11 (3.62)****
Net worth: Real assets – liabilities	------	------	------	------	------	0.0003 (3.84)**
Stock of Production Capital	0.04 (4.01)**	------	------	------	------	------
Stock of Consumer Durables	------	-0.002 (-4.75)**	------	------	------	------
Stock of Grain Stock	------	------	-0.07 (-8.58)**	------	------	------
Owned Land	------	------	------	0.63 (2.22)*	------	------
Stock of Net Borrowings	------	------	------	------	-0.0002 (-0.47)	------
	-51.93 (-1.00)	-5.44 (-0.14)	77.26 (1.78)	2.07 (0.31)	-116.75 (-2.33)	-65.67 (-1.19)
Number of Observations	7703	7703	7703	7703	7703	7703

Panel B: Based on Seasonal Data

Dependent Variables:	**△Production Capital**	**△Consumer Durables**	**△Crop Inventory**	**△Input Inventory**	**△Financial Assets**	**△Cash holdings[2)]**
Explanatory Variable:	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)	Parameter Estimate (t-ratio)
Crop Income in peak season (Transitory income)	**0.06 (2.37)***	0.03 (1.58)	**0.36 (7.05)****	**0.02 (8.03)****	0.06 (1.59)	**0.41 (5.14)****
Net worth: Real assets – liabilities	------	------	------	------	------	-0.025 (-2.23)*

Stock of Production Capital	0.04 (4.08)**	------	------	------	------	------
Stock of Consumer Durables	------	-0.005 (-0.37)	------	------	------	------
Stock of Grain Stock	------	------	0.15 (0.63)	------	------	------
Owned Land	------	------	------	-1.48 (-1.23)	------	------
Stock of Net Borrowings	------	------	------	------	-0.02 (1.01)	------
Constant	-271.22 (-0.78)	-10.16 (-0.05)	-0.43 (-0.001)	-61.21 (-2.61)	-514.98 (-0.96)	-287.40 (-0.33)
Number of Observations	504	504	504	504	504	504

Note: [1)]Square takes negative value when the deviation is negative. [2)]Number in parentheses is *t* ratio. **= significant at 1% level. *= significant at 5% level. †= significant at 10% level.

Table 6 Estimations of the Reduced Form Income Equations based on the ICRISAT data from 2009-2012

	Monthly Income	
Variable	Parameter Estimate	*t*-ratio
Transitory Factors		
Rainfall variables:		
(R1- mean of R1) :R1 =r0 + r-1 + r-2 +r-3	9.19	(2.88)*
where r-t is the t-th lagged monthly rainfall		
(R1- mean of R1)*(Owned Land)	-0.86	(-3.05)*
(R2- mean of R2) :R2 =r-4 + r-5 +r-6 +r-7	12.87	(3.48)**
(R2- mean of R2)*(Owned Land)	-1.14	(-3.41)**
(R3- mean of R3) :R3 =r-8 + r-9 +r-10 +r-11	8.41	(1.83)
(R3- mean of R3)*(Owned Land)	-0.78	(-2.03) †
Seasonal Dummies:		
Whether July or not	-684.78	(-1.08)
Whether Aug or not	1304.32	(1.65)
Whether Sept or not	1039.87	(1.31)
Whether Oct or not	2199.24	(3.30)**
Whether Nov or not	1140.77	(1.52)
Whether Dec or not	-673.11	(-1.06)
Whether Jan or not	1167.83	(1.55)
Whether Feb or not	957.93	(1.75)
Whether Mar or not	1249.56	(1.90)
Whether Apr or not	1594.66	(2.32) †
Whether May or not	3112.72	(3.97)**
Permanent Factors		
Village dummies: [1)]		
Whether Shirapur or not	3352.02	(4.89)**
Whether Aurepalle or not	3564.00	(4.84)**
Sex/ age/ education variables:		
Number of people aged 0-5	660.73	(2.37) †
Number of males aged 6-11	315.03	(1.26)
Number of females aged 6-11	-910.40	(-5.35)**
Number of males aged 12-17	561.56	(3.56)**
Number of females aged 12-17	-446.66	(-2.29) †
Number of males aged 18-64		

with primary education or less	2690.79	(9.44)**
with middleschool education	2411.26	(7.74)**
with highschool education	2881.85	(16.99)**
with intermediate education	1587.41	(5.42)**
with higher education	1856.04	(3.96)**
Number of females aged 18-64		
with primary education or less	-329.74	(-1.03)
with middleschool education	1347.64	(2.70)*
with highschool education	961.89	(2.19) †
with intermediate education	2321.40	(3.74)**
with higher education	1374.18	(1.99) †
Number of males aged 65 or more	-276.17	(-1.12)
Number of females aged 65 or more	421.49	(1.21)
Variables on the caste[1)]		
Backward Caste	-880.68	(-1.04)
Forward Caste	-576.36	(-1.14)
Nomadic Tribe	1918.43	(3.33)**
Scheduled Caste	1383.56	(2.02) †
Other Caste	-240.98	(-0.34)
Owned Land (ac.)	-100.89	(-2.87)*
Share of Owned Land which is Irrigated	-629.40	(-1.05)
Stock of Livestock (Rs.)	-52.97	(-8.51)**
Constant	-930.29	(-1.18)
Number of Observations	2902	

Note: Number in parentheses is *t* ratio. **= significant at 1% level. *= significant at 5% level. †= significant at 10% level. [1)] Dummy variable.

Table 7 Two-step Random-effects GLS Estimates of Savings Equations using 2009-2012 ICRISAT data

Dependent Variable:	**Case (A) ΔCapital Assets[1]**		**Case (D) -ΔLoan Balance**		**Case (F) Total Savings [3]**	
Explanatory Variable:	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
Transitory Income	**0.01**	**(0.30)** [2]	**0.45***	**(2.48) †**	**0.93*****	**(31.47)****
Permanent Income	**0.07**	**(0.38)**	**-0.55**	**(-1.34)**	**1.41*****	**(6.72)****
Number of Observations	**548**		**2260**		**2902**	

Dependent Variable:	**Case (H) ΔLivestock**		**Case (I) ΔProduction Capital**		**Case (J) ΔConsumer Durables**	
Explanatory Variable:	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
Transitory Income	**0.00**	**(0.22)**	**0.01**	**(0.29)**	**0.00**	**(0.28)**
Permanent Income	**-0.43**	**(-1.13)**	**0.06**	**(0.27)**	**-0.01**	**(-0.25)**
Number of Observations	**2902**		**548**		**548**	

Note:The capital letter designation of the cases corresponds to their lower case designation in Table 3 for ease of comparison. [1] Capital assets include Consumer Durables and Production Capital [2] Numbers in parentheses are *t* ratio. **= significant at 1% level. *= significant at 5% level. †= significant at 10% level. [3] Total Savings = Income- Consumption.

Appendix 1: Constructions of Monthly and Seasonal Asset Variables

Based on household transaction and crop-production modules, we have calculated the following monthly variables. All of these are household variables. Seasonal variables are constructed by aggregating the monthly variables during the agricultural slack season from April to September and the peak season from October to March.

Real Monthly Income is the sum of monthly income from agriculture, labour, trade, handicrafts and net transfers

$$Y = Y_{agriculture} + Y_{labour} + Y_{trade} + Y_{handicrafts} + NetTransfers \quad \text{(A)}$$

Real Monthly Consumption is sum of monthly expenditures on all the food and non-food expenditures

$$Consumption = \sum Expenditure_{food/non\text{-}food} \quad \text{(B)}$$

Financial Savings is the Net Real Monthly Increase of Financial Assets based on the difference between financial assets and the withdrawal

$$FinancialSavings = Savings + Deposits + LifeInsurance + Others - Withdrawal \quad \text{(C)}$$

Credit is the Net Real Monthly Decrease in Liabilities

$$Credit = Lending - Borrowings + Repayment \quad \text{(D)}$$

Change in Financial Assets – denoted as $-\Sigma \triangle B_{ijt} P_{ijt}$ above – is the sum of (C) , (D) and income from gift and others

The Net Real Monthly Increase of All the Livestock is based on bullocks, cows, young cattle, buffalo, young buffalo, horses, donkeys, goats, sheep, pigs, poultry, and others

$$\Delta Livestock = Purchase - Sale - LossLivestock \quad \text{(E)}$$

[17]

The Net Real Monthly Increase of Main Production Capital is based on dry land, wet land, wells, tanks, cattle sheds, cattle yards, storage facilities, oil or electric pumps

$$\Delta MainProdCapital = Purchase - Sales - LossProdCapital + ExpenditureOnProdCap \quad \text{(F)}$$

Net Real Monthly Increase of All Consumer Durables which are *not* included in Consumption, e.g. jewellery, cycles, furniture etc.

$$\Delta MainDurables = Purchase - Sales - LossDurables + ExpenditureOnDurables \quad \text{(G)}$$

Change in Capital Assets – referred to as $-\Sigma \triangle K_{ijt} P_{ijtt}$ above - is the sume of (F) and (G)

Savings is computed as the difference between Income and Consumption

$$Savings = Income - Consumption \quad \text{(H)}$$

Monthly Change in Currency – referred to as $-\triangle M_{jt}$ above – is the difference between the acquisition of cash and the use thereof.

[17] Loss of livestock due to death, theft etc.

Change in Crop Inventory – referred to as as $-\Sigma \triangle S_{ijt}P_{ijt}$ above – is the sume of crop production and purchase less crop sales and the consumption of self-produced crops

$$\Delta CropInventory = CropProduction + CropPurchase - SaleCrops - ConsumptionCrops \quad (I)$$

Change in Input Inventory – referred to as $-\Sigma \triangle I_{ijt}P_{ijt}$ above – is the net change in fertilisers, manure, pesticides, and insecticides .

$$\Delta InputInventory = \Delta Fertilisers + \Delta Manure + \Delta Pesticides + \Delta Insecticides \quad (J)$$

All of (A), (B), (C), (D), (E), (F), (G), (H), (I) and (J) are in monthly terms and deflated by the village-level monthly CPI – referred to as $P_{ct}Y_{it}$ above.

Appendix 2: Cluster analysis on the effects of different household assets to cope with shocks
Drawing upon Kusunose and Lybbert (2014), we have carried out cluster analysis to further investigate the effects of different household assets to cope with income shocks. We have used *k-means* clustering method through which *k* clusters are created, each containing households of similar characteristics or trends (in our case, dissaving of certain assets). The method initially allocates households randomly into the *k* clusters, then rearranges them such that it minimizes each cluster's within variation to keep similar households in each, and maximizes cross-cluster variation.(ibid., 2014). This method is discussed in further detail in Brown *et al.* (2006).

We have clustered all the monthly observations according to whether a household reduced a particular type of asset, namely, livestock, production assets, consumer durables and crop inventory, or any combination of these assets in case the household reduced more than one type of assets. For cluster analysis, binary variables are defined as whether a household reduced more than 10% of the initial asset balance of each type of asset in a particular month. We do not include cash balance as the initial balance of cash holdings is unavailable. Credit balance – or liability - is not considered either because the meaning of the balance is different from that of other assets with positive values.

Although this is a descriptive analysis and subject to limitations (e.g. ignoring the panel structure of the data), comparisons of means of total or food consumption per capita across different clusters would provide an insight into whether the use of more than one type of asset would facilitate household risk coping. Also, we are able to characterize different types of households by comparing other variables, such as consumption or the initial stock of various household assets.

We have identified eight mutually exclusive clusters in Appendix Table according to whether a household sold, or reduced more than 10% of the stock of, one or more types of assets in a particular month. Cluster 1 is the benchmark case where households did not sell any types of asset. Clusters 2 to 5 correspond to the cases in which households sold only one type of asset, namely, livestock, production capital, consumer durables and grain stock in a particular month. Cluster 6 is the case where a household sold livestock and production capital at the same time, while consumer durables and grain were dissaved simultaneously for Cluster 7. Those four types of asset reductions appear in Cluster 8.

The results will have to be interpreted with caution as the figures are unconditional means of observations for clustered observations. However, it is found that (i) clusters of households selling only livestock (Cluster 2) or only consumer durables (Cluster 4) have consumption lower than the benchmark case (Cluster 1) and these clusters of households are characterized with low levels of initial assets which were sold; (ii) households selling only production capital (Cluster 3) had consumption not much different from the benchmark case, which is consistent with our econometric results (Case (a) of Table 3); (iii) selling grain stock appears to be the most effective risk-coping strategy (Cluster 5) resulting in the highest total or food consumption – which is in line with our econometric result (Case (b) of Table 3), but these households tend to have higher levels of not only grain stock, but also other assets; (iv) in general there is no clear evidence to show that the use of multiple assets facilitate keeping the consumption levels (e.g. Clusters 6 and 7); and (v) households selling all the four assets had consumption (Cluster 8) only slightly lower than the benchmark case, but this is probably because such a drastic reduction of assets was possible for households with higher levels of initial assets.

In sum, the results of cluster analysis are broadly consistent with those of econometric analyses in Tables 3 and 5, but they do not imply that the use of multiple assets is more effective than relying on only a single asset for coping with monthly income shocks.

Appendix Table

		Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8
		No pattern	Sold Live-Stock [1]	Sold Produc-tion Capital [1]	Sold Consumer Durables [1]	Sold Grain [1]	Sold Livestock and Production Capital [1]	Sold Consumer Durables and Grain [1]	Sold Livestock, Production Capital, Durables and Grain [1]
	No. of Observations	6674	2176	69	223	1059	886	484	2237
Means of Variables									
Consumption	Per Capita Food Consumption	21.5**	13.85**	18.59	12.32	23.72*	7.96**	8.11**	16.22
	Total Per Capita Consumption	22.7**	14.89**	20.49	13.08	25.16*	8.58**	8.76**	17.26
Initial Stock at the Beginning of the year	Initial stock of Consumer Durables	3701.97**	1505.23**	4535	6.95**	4508.04**	1353.76**	0**	3182.95
	Initial stock of grain stocks	554.78**	207.08**	432.06	1273.63**	653.94**	217.8**	48.45**	517.66
	Net Borrowing at the Beginning of the year	2123.42**	1312.67**	2402.98	140.14**	2208.45*	1546.32	184.64*	1805.6
	Initial Stock of Livestock	2577.33**	478.57**	2676.04	1480.27**	2912.93**	866.36	2525.31*	1977.45*
	Initial Stock of Production Capital	1756.38**	588.78**	765.97	750.36	1686.66	818.09	1134.43	1352.96

1. A clustering variable for "selling asset" is defined as a binary variable, taking 1 if a household reduced more than 10% of the initial stock of household asset, and 0 otherwise. We used four clustering variables for livestock, production capital, consumer durables, and grain stock.

2. * shows that the mean differs from the mean of the rest of the sample at 5% significance, while ** is used for the cases significant at 1% level.