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Risk and Saving in Northern Nigeria

by Christopher Udry[*]

Department of Economics
Northwestern University
Evanston, IL 60208
udry@nwu.edu

People who live in the rural areas of poor countries often must cope not only with severe poverty but with extremely variable incomes. The study of the implications of this variability for individual utility, production decisions and the evolution of economic institutions has been a central theme of recent work in development economics.[1] However, income variability implies consumption variability only if households do not use *ex post* mechanisms to insulate consumption from the income fluctuations. One such mechanism is cross-sectional risk pooling through insurance. In earlier work, I have examined the credit-*cum*-insurance arrangements used by rural households in northern Nigeria (Udry [1990,1994]). The complementary *ex post* mechanism is the use of saving behavior to smooth income fluctuations over time. This paper provides an analysis of the extent to which the same Nigerian households use their assets to cope with risk.

When insurance markets are incomplete, saving and credit transactions assume a special role by allowing households to smooth their consumption streams in the face of random income fluctuations. The first goal of this paper, therefore, is to examine the hypothesis that households dissave when confronted with adverse shocks to their incomes. In section 2, I explore this issue using a unique data set which includes household level information on the receipt of random production shocks over the course of a single agricultural year. The availability of this direct measure of transitory shocks at the household level means that shocks need not be inferred from the residual between actual income and some measure of permanent income.[2] The analysis shows that the asset drawdown upon the receipt of an adverse shock is large (relative to per-capita GNP) and statistically significant.

This result must be interpreted with care. It is derived from data on changes in asset stocks and the receipt of discrete transitory adverse shocks on farmers' fields (e.g., flooding). For two distinct reasons, these data do not permit a direct test of optimal saving behavior. First, the saving data are constructed from differences in asset stocks over time. If the asset stock data are comprehensive, then asset accumulation corresponds to actual saving and one can speak confidently of the responsiveness of saving to transitory shocks. However, if the asset stock data are incomplete, then variation in the inventories of the subset of assets which are observed need not track saving. In section 2, I draw on external evidence to evaluate the likelihood that significant saving occurs through assets not included in these data. In addition, I quantify the differing responsiveness of different assets to household risk in section 3. I show that grain inventories grow more slowly upon the receipt of an adverse shock, but that livestock holdings are unaffected. This is consistent with consumption-smoothing via buffer stocks when there are direct links between the ownership of assets and production. If livestock ownership is subject to diminishing returns while other potential assets (in particular, grain stocks) are not, then consumption smoothing should be effected exclusively through variations in holdings of grain as long as these are positive.[3] However, it remains true that if there is significant saving in unobserved assets, then the observed relationship between grain stock accumulation and the receipt of transitory shocks need not reflect consumption-smoothing. It could be an outcome of a variety of other mechanisms which could cause shifts in the composition of portfolios contingent upon the receipt of an unanticipated shock. A set of alternative hypotheses are discussed in section 3. It will not be possible to distinguish definitively between these alternatives using these data alone. However, supplementary evidence is presented which suggests that these specific alternatives to a consumption-smoothing interpretation of the results are incorrect.

The second reason that these data do not permit a direct test of optimal saving behavior is the absence of income or consumption data. Suppose that the asset data are complete, so that saving is measured correctly. If income in period t depends on the realization of transitory shocks Z_t defined so that $Y_t'(Z_t) < 0$, then a minimal implication of standard models of intertemporal choice is that if $s_t \equiv A_t - A_{t-1} \equiv Y_t - c_t$, then $\partial s_t/\partial Z_t < 0$, so that transitory changes in income are not fully reflected in current consumption. Section 2 provides evidence that $\partial s_t/\partial Z_t$ is negative. This is sufficient (again, if saving is measured correctly) to show that households use their saving behavior to smooth variations in income, because consumption changes less than *pari passu* with income. However, this finding is not entirely surprising. It does not imply that households' saving behavior corresponds to the PIH nor to a more general model of intertemporal choice. Even if households simply set $c_t = \alpha Y_t$ ($\alpha < 1$), engaging in no forward-looking behavior, one would observe $\partial s_t/\partial Z_t < 0$. With neither consumption nor income data with which to match the saving data, it is impossible to quantify the responsiveness of saving or consumption to income shocks and therefore to test directly particular models of consumption-smoothing. Instead, the data can be examined from a number of angles to provide suggestive evidence distinguishing passive saving behavior from forward-looking management of asset stocks designed to smooth consumption. In section 4, I examine the households' participation in asset markets to disentangle passive accumulation of stocks in response to income variation from the use of specialized buffer stocks. Section 5 exploits the panel nature of the data set to explicitly test the hypothesis of forward-looking behavior: do households save in anticipation of the receipt of adverse shocks?

1. Data and Geographical Setting

The study is based on a nine-round survey of 200 farming households I conducted in northern Nigeria. The survey was designed to yield reliable and uniquely detailed data concerning wealth and asset market transactions, as well as information about the incidence of random production shocks.[4]

Saving - There is data on each household's stock of grain and farm inputs, livestock, and goods for trading at three points during the survey year (denote these by $A_{k,p}$, $p \in \{0,1,2\}$). In addition, I have data on each household's cash holdings for each round of the survey, but this information must be considered very unreliable: I believe that respondents often understated their true cash holdings in our interviews. Cash is therefore excluded from the measure of saving used in most of this paper. Finally, there is data on each household's landholdings and land market transactions. However, only five plots were sold or purchased by sample households during the survey year. This paper, therefore, focuses on assets which are more liquid than land.

Saving in any asset k can be defined for two periods for each household: $s_{kt} \equiv A_{k,t} - A_{k,t-1}$ for $t \in \{1,2\}$ and total saving $s_t = \sum_k s_{kt}$. Period 1 runs from April to September and period 2 covers September to February. Summary statistics are reported in Table 1. Mean saving is strongly seasonal, as can be expected in an agrarian economy, although it is positive in each period. The saving measure generated by data on changes in asset ownership is supplemented by data on the households' participation in asset market transactions.

Random Shocks to Income - The data on the realization of adverse production shocks on the sample households' farms is based on a count of specific incidents of discrete adverse events on each plot. These events are transitory in nature and should not affect income after the current harvest. Dates of the events were not recorded, but for most events an approximate date can be inferred (for instance, wind damage to maize only occurs late in the season; flooding causing poor germination of millet occurs early). The events are divided into period 1 (Z_{j1}) or period 2 (Z_{j2}) occurrences. In each period, the index of self-reported adverse shocks is a weighted average of the number of these negative events, where the weights are the sizes of the plots on which they occur. Two indices of adverse shocks are constructed for each household, for each period, one for each type of land (upland or lowland) on which they occurred. The two most common adverse events were waterlogging and insect attacks (accounting for 54 percent of all adverse shocks), followed by animal, bird, wind and weed (*wutawuta*) damage.

Timing - The relative timing of the receipt of random shocks, the realization of the effect of these shocks on income, and measured saving behavior is important for the interpretation of the results. The harvest period begins in period 1, when early-planted millets on upland fields mature and lowland garden crops are harvested. Harvesting continues into period 2, when most upland grains are harvested. The effects of period 2 shocks (Z_{j2}) are realized on income in period 2, and thus should be reflected in period 2 saving if assets are used as buffer stocks. I attempted to define early period shocks (Z_{j1}) so that their impact on income would be realized in period 1, but the imprecise nature of the data implies that, in addition, period 2 income might be affected by Z_{j1}. If this is the case, then the effect of Z_{j1} on period 1 saving becomes ambiguous.[5] I provide a test for this possible effect in section 2.

2. Responses of Saving to Income Shocks

Saving by household j in period t (s_{jt}) is assumed to be a linear function of a vector of household characteristics (X_j) which determine the level and variance of the household's permanent income, and which indicate the stage of the household in its life cycle. Saving may also depend on the season of the year and on village-level shocks to income; both of these sources of saving variation are captured by an indicator of the period (d_t). Finally, saving may respond to the receipt of transitory idiosyncratic production shocks (Z_{jt}):

$$(1) \quad s_{jt} = d_t\alpha + X_j\beta + Z_{jt}\gamma + d_tX_j\delta + v_{jt}.$$

The data cover only one year, so the effects of seasonality and aggregate shocks are collinear. In order to disentangle the effects of these different sources of income and saving variation a time series spanning different years would be required. The effects of seasonality or aggregate shocks on saving might depend on household characteristics, hence I have included interactions between X_j and d_t. For instance, one might expect the extent of land holdings to have an effect on seasonal variation in saving (larger landholders would be expected to save more than smaller landholders during a period which spans the harvest relative to their saving during the farming season). Similarly, an aggregate shock to rainfall might have a larger effect on the saving of larger landholders. γ is the product of the effect of adverse transitory shocks on transitory income and the effect of transitory income on saving. If assets are used as buffer stocks against the receipt of adverse shocks, then $\gamma<0$.

This formulation requires the assumption that idiosyncratic shocks across the two periods are independently (though not necessarily identically) distributed.[6] The realization of the shock in period 1 therefore provides no information about the shock due to occur in period

2. If this is so, then the shocks are transitory and the simple behavior described in equation (1) can capture the use of assets as buffer stocks. Aggregate shocks can be correlated over time without affecting the results, for their influence on saving is captured in α and δ.

Feasible generalized least squares estimates of (1) are presented in the first column of Table 2. The null hypothesis that net saving is unaffected by the receipt of adverse idiosyncratic shocks can be rejected.[7,8] The Wald test of the joint significance of the two shock variables is distributed as $\chi^2(2)$ and has a value of 8.00 (p=.02). The results are consistent with simple models of consumption smoothing: saving is lower in those households subjected to adverse idiosyncratic shocks on their upland plots, though there is no statistically significant relationship between shocks on lowland plots and saving. Moreover, the responsiveness of saving is very large. Nigeria's 1988 GNP per household (at the average household size of this sample, 8.5 members) was N10,500. The receipt of a one standard deviation adverse shock on a farmer's upland plots is associated with dissaving of N1,584 or over 15 percent of average Nigerian household income (mean saving per period is N2,746).[9,10]

This finding implies that households are not completely insured against the receipt of these idiosyncratic shocks and therefore provides corroborating evidence for the conclusion of Udry (1994) that a fully Pareto efficient allocation of risk is not achieved in these villages. There, it is shown that there is much stronger evidence of insurance (through state-contingent credit transactions) against shocks on lowland plots than against shocks on upland plots, probably as a result of the better availability of information concerning shocks on lowland plots. The differential effects on saving of shocks on upland and lowland plots, therefore, may reflect the relative availability of insurance against these different types of idiosyncratic shocks.

The effects of seasonality and aggregate shocks on saving are mediated by land ownership. Owners of additional upland land save significantly more during the second period relative to the first period, while owners of additional lowland land save significantly less. This is consistent with the different timing of input application and harvests on the two types of land. The main farming expenses on upland plots occur during period one, while the main upland harvest occurs during period two. In contrast, much of the value of lowland harvests is accrued during period one. In addition, saving displays significant variation across villages and households which had been wealthier in the past (when the household head first married, on average 16 years before the survey) have significantly higher current saving.

I have equated accumulation of the measured assets (grain, livestock and trade stocks) with "saving". This is correct only if the asset stock data are complete. We can not rule out the possibility that there are simultaneous unobserved movements in other asset stocks which compensate for the observed changes, causing us to misinterpret portfolio adjustments for saving behavior. These households do have assets which are not included in measured saving, several of which need not concern us. I have shown elsewhere (Udry, 1994) that there is no significant responsiveness of net lending to the realization of the shocks examined in this paper. The value of furniture, farm equipment, vehicles and housewares (for which no measure of saving can be constructed, because it is measured at only one point during the survey) averages less than N1300 per household, too small to account for any significant countervailing accumulation. It is also unlikely that the responsiveness of the accumulation of *kayan ado*, the ornaments of women, to the realization of these shocks is large. Callaway

(1987) argues that the purchases of *kayan ado* are financed entirely by the earnings of women (who do not farm) and that they are virtually never sold (they serve as dowry for daughters). If Callaway is approximately correct, then there is little room for significant variation in saving in *kayan ado*, because the average wage for women in these villages is under N4 per day. The response of cash balances to shocks is addressed in section 3. Jacoby and Skoufias (1992) show that investments in children's education in India is responsive to the realization of adverse shocks. It is unlikely that there is a similarly important response in northern Nigeria: less than 5 percent of the children in the sample attend school. Accumulation of these assets is unlikely to exhibit a responsiveness to the realization of shocks of the same order of magnitude as that shown by the measured assets in Table 2. Moreover, to the extent that there is a response, it is difficult to imagine that it would be opposite to that shown by the measured assets. However, there is also unmeasured investment in the quality of farmland (mainly through erosion control and brush-clearing). The adverse shocks of this paper occur on the farmers' plots and conceivably could affect the returns to investment in land improvements. It is possible that the realization of an adverse shock spurs an unobserved investment in land improvement, thus offsetting some or all of the dissaving in the measured assets. This possibility cannot be addressed with these data, and should be borne in mind as the results are interpreted.

3. Portfolio Effects of Income Shocks.

Data are available on the composition of the households' portfolios, so equation (1) can be estimated for each of the disaggregated components of saving (one is redundant, so saving in trade stocks is dropped).[11] FGLS estimates of the determinants of saving in grain and livestock are reported in the second and third columns of Table 2. Estimates for cash holdings are reported in the final column.

Livestock saving is not affected by idiosyncratic shocks. In fact, the point estimates of the effect of shocks are positive, albeit insignificant.[12] The effect of the receipt of adverse shocks on saving is realized through changes in grain stocks. It is possible to reject the null hypothesis that saving in the form of grain is unaffected by idiosyncratic shocks; the Wald $\chi^2(2)$ test statistic is 16.46. The point estimate implies that a one standard deviation shock on upland plots is associated with a N2,146 reduction in saving in the form of grain (the mean of grain saving per period is N991). Cash holdings also grew significantly less rapidly in households subject to an adverse shock on upland plots. A one standard deviation adverse shock is associated with a N261 reduction in cash saving. Recall, however, that the cash data are suspect.

When households receive transitory shocks to their incomes, they respond by reducing their grain and (to the extent that the results are not compromised by data quality) cash saving, but livestock saving is unaffected. This pattern is consistent with optimal saving behavior when a subset of the assets held by households is used directly in production. Livestock production in this farming system requires inputs of land for grazing and household labor for herding, watering and gathering supplemental food for the animals.[13] There are not complete rental markets for livestock. There is a history of livestock tenancy in this region, in which farmers let out cattle to specialized herders (see Stenning, 1959; Baier, 1980; Frantz, 1975). However, less than 5 percent of the value of livestock owned by these households was kept in such arrangements. Given household characteristics, therefore, ownership of livestock is subject to diminishing returns.[14]

The important alternative asset held by these households is grain. The return to holding grain is not subject to diminishing returns; it is determined by the seasonal change in the grain price and the direct loss of stored grain to pests, each of which are constant per unit of grain stored.[15] Given diminishing returns, the amount of livestock held by the household is determined by considerations of productive efficiency, and consumption-smoothing is effected through the sale or purchase of only those assets (mostly grain) not used in production and not, therefore, subject to diminishing returns.

It should be noted that the results of Table 2 are also consistent with a number of other mechanisms which could cause shifts in the composition of households' portfolios contingent upon the receipt of an unanticipated income shock. Two of the more obvious mechanisms are indivisibilities or transaction costs associated with livestock. Neither of these possibilities, however, are likely to be at work in these data. On average, seventy percent of the value of the livestock held by these households is composed of sheep and goats, the prices of which range from N50 to N200, much less than the dissaving contingent upon a one s.d. shock. Indivisibilities are not a hindrance to the use of livestock to smooth consumption. Nor do transaction costs seem to be higher for goats and sheep than grain. They are exchanged in different sections of the same market, and both livestock and grain transactions are extremely frequent in these markets. Nor are transportation costs of small livestock and grain to the markets significantly different.

If the shocks contain information concerning the distribution of future returns to holding various assets, than a change in the rate of accumulation of grain might reflect portfolio adjustments rather than consumption-smoothing. However, these shocks are idiosyncratic. They cannot affect future price movements. Moreover, they are plot-specific and should not affect herding activities or losses to stored grain, so future returns are unaltered. If there are transaction costs in the grain market, a transitory shock to grain production might be associated with a change in the rate of growth of grain stocks through inventory control choices rather than saving decisions. This possibility cannot be excluded with these data. However, transaction costs are extremely low. There is no statistically significant difference between the (month-specific) sale and purchase price of grain to these farmers (based on 1,150 recorded transactions). The point estimate is that the purchase price exceeds the sale price by only 2.5 percent.

Finally, these results are consistent with the possibility that households myopically save a fraction of the output each of their activities. These shocks affect grain production, so a simple proportional saving rule implies that the shocks affect grain inventories but not livestock holdings. The results with respect to cash provide some evidence that assets other than grain respond to shocks. For additional evidence which suggests more sophisticated saving behavior, we turn to the grain market.

4. The Grain Market

Adverse shocks reduce farm profit by both reducing output and inducing higher expenditures.[16] If consumption is stabilized through saving, this implies larger sales of grain contingent upon the realization of an adverse shock. A simple model will make the intuition clear. Suppose that farm profits are a function of variable inputs L_t and the transitory shocks Z_t:

(2) $F_t = F(L_t, Z_t) - w_t L_t.$

w_t is independent of the idiosyncratic shocks Z_t, so $\partial^2 F/\partial L \partial Z > 0$ implies that the realization of adverse shocks induces households to use variable inputs more intensively. This is related to grain market transactions through the budget constraint

(3) $y_{gt} = s_{gt} + c_{gt} + T_{gt}$, where

(4) $T_{gt} = p_t \cdot c_{ot} + w_t(L_t - L_t^s) - p_{\kappa t} T_{\kappa t}.$

y_{gt} is the grain harvest, s_{gt} is net grain saving, c_{gt} is grain consumption and T_{gt} is the object of current interest, net grain sales in period t. Net grain sales equal expenditure on non-grain consumption items ($p_t \cdot c_{ot}$) plus net purchases of variable inputs minus net sales of livestock, all valued in terms of grain. If consumption-smoothing is substantially effective, then c_{ot} and L_t^s are not affected by Z_t. Section 3 argues that optimal livestock holdings are not affected by realizations of Z_t. Furthermore, these shocks affect crop, not livestock, production, so $T_{\kappa t}$ is independent of Z_t. Then $\partial L_t/\partial Z_t > 0$ implies $\partial T_{gt}/\partial Z_t > 0$. The increased expenditure on inputs required by the realization of an adverse shock is funded through increased net sales of grain.

The monthly net grain sales figures for each household are aggregated into three periods, corresponding to the periods for which there is information on the receipt of shocks. Period zero runs from February to April. No adverse shocks were recorded during this period, which ends before the upland farming seasons begins (so $Z_{j0}=0 \; \forall \; j$). Periods 1 and 2 are defined as in section 2. Actual net grain sales are not observed because households were instructed to report only "important" sales or purchases of grain. This results in censoring of reported net grain sales when actual sales are near zero (37 percent of the observations). Each household's interpretation of "important" may be different, hence the degree of censoring may vary across households. This can be captured by fixed effects which differ when observed sales are positive (λ_j^s) and when observed purchases are positive (λ_j^p). The degree of censoring in reported net grain sales by household j depends on (λ_j^s-λ_j^p)≥0 (there is no censoring if $\lambda_j^s=\lambda_j^p$). Net grain sales (T_{jt}) are

$$(5) \quad T_{jt} = \begin{cases} d_t\alpha + Z_{jt}\gamma + d_t \otimes X_j\delta + \lambda_j^p + \upsilon_{jt} & \text{if } d_t\alpha + Z_{jt}\gamma + d_t \otimes X_j\delta + \lambda_j^p + \upsilon_{jt} > 0 \\ 0 & \text{if } -\lambda_j^p > \upsilon_{jt} > -\lambda_j^s \\ d_t\alpha + Z_{jt}\gamma + d_t \otimes X_j\delta + \lambda_j^s + \upsilon_{jt} & \text{if } d_t\alpha + Z_{jt}\gamma + d_t \otimes X_j\delta + \lambda_j^s + \upsilon_{jt} < 0 \end{cases}$$

The vector d_t contains two elements which indicate period 1 and period 2. Table 3A-B reports the results of the estimation of (5).[17] The hypothesis that the coefficients of the model are equal when the household sells grain and when it purchases grain is firmly rejected (the $\chi^2(8)$ Wald test statistic is 246), therefore the results are reported separately for the two cases in Table 3A. However, the hypothesis that the coefficients of the idiosyncratic shock variables are the same in the two cases cannot be rejected (the $\chi^2(2)$ test statistic is 1.05). The two estimators of these coefficients, therefore, are optimally combined to yield the estimates reported in Table 3B (see Hansen [1982]). The point estimate indicates that a one standard deviation adverse shock on a household's upland farm is associated with an N4,668 increase in grain sales during that period (recall that the estimate of the reduction in grain saving associated with the receipt of a shock is N2146). The final column of Table 3A provides estimates when the dependent variable is *gross* sales of grain. These estimates show a strong positive correlation between the receipt of adverse shocks on uplands (and thus lower grain production) and additional gross sales of grain, providing additional evidence that these changes in grain stocks reflect portfolio adjustment decisions rather than simple proportional saving rules.

5. Do Households Save in Anticipation of Shocks?

It may be that the idiosyncratic shocks discussed in this paper can be foreseen by farmers.[18] If so, then it is possible to test explicitly for forward-looking behavior. If shocks are predictable, then standard intertemporal models imply that the household would have saved in advance of the occurrence of the shock. Saving would predict the shock, rather than *vice-versa*. Suppose that the PIH is correct. Campbell (1987) shows that saving in period t is

$$(6) \quad s_t = -\sum_{i=1}^{\infty} (1+r)^{-i} E_t(y_{t+i} - y_{t+i-1}).$$

y_t is non-interest income in period t and the expectation is taken with respect to the information available to the household at time t. So current saving equals the discounted value of expected future declines in income. Now suppose that income is stationary and that a 1 s.d. transitory shock reduces income for a single period by, say, ϵ.[19] If farmers realize in period t that they will be subject to an adverse shock in period t+1, then $s_t=\epsilon r/(1+r)^2$, or approximately 15 to 20 percent of ϵ (for $.2<r<.4$). If information concerning the possible receipt of shocks in the latter half of the season (period 2) becomes available during period 1, then

$$(7) \quad \begin{aligned} s_{j1} &= X_j\beta + Z_{j1}\gamma + Z_{j2}\gamma_2 + \upsilon_{j1} \\ s_{j2} &= \alpha + X_j\beta + Z_{j2}\gamma + X_j\delta + \upsilon_{j2} \end{aligned}$$

where $\gamma_2>0$. Equation (7) can be applied both to overall saving and to saving in the form of grain. FGLS estimates of the determinants of overall saving and grain saving are presented in Table 4. The relationship between the realization of idiosyncratic shocks on upland plots and current saving remains significantly negative and of the same magnitude as reported in Table 2. Moreover, in period 1 both overall saving and grain saving are significantly affected by anticipations of period 2 shocks on upland plots. Both estimates provide evidence that households increase their saving in anticipation of future shocks on upland plots. The point estimates imply that the responsiveness of saving to anticipated shocks is quite large. A one s.d. shock on upland plots in period 2 is associated with increased saving in period 1 of about N1500. This is of the same order of magnitude as the dissaving which occurs contingent upon the realization of an adverse shock, and is much larger than would be expected given the PIH and our assumption that income is stationary and the shocks are transitory. How can this be interpreted?

First, footnote 10 implies that period 1 and 2 shocks may not be equivalent. The point estimates indicate that a 1 s.d. adverse shock in period 2 is associated with dissaving (and thus an estimate of ϵ) of about N2500. Anticipatory saving of about N1500 is still too large to reconcile with the PIH and transitory shocks, but the contrast is not as dramatic as implied above.

Second, the shocks (e.g., weed infestation or erosion) may be persistent, so that a sequence of relatively poor harvests can be expected. This implies that anticipatory saving upon the realization that a shock will occur is larger than $\epsilon r/(1+r)^2$, while dissaving contingent upon the initial realization of the shock remains ϵ. If in addition, households have a relatively short time horizon (thus violating the PIH), anticipatory saving is yet larger, and the dissaving contingent upon the occurrence of the shock is smaller (implying that ϵ is larger than estimated above). A persistent shock and short time horizon can reconcile the results of

Tables 2 and 4.

Finally, the shocks might be endogenous. Despite my efforts to choose uncontrollable events as shocks, it is possible that lower labor expenditures and thus relatively higher saving increases the probability that a shock will be realized. Higher saving, therefore, *causes* the "shock". This interpretation implies that a reduction in expenditure (and thus increased saving) of about N1500 causes, in expectation, a one s.d. shock, itself costing (and thus inducing dissaving to smooth consumption) about N1500. It is not possible to distinguish between these interpretations with these data. There is some evidence that near-future upland "shocks" are foreseen and that, in anticipation, households increase their current saving. However, the evidence is only suggestive and it is not easily reconciled with the PIH.

6. Conclusions

It has often been suggested that an important motivation for saving in poor agricultural societies is to use asset stocks to stabilize consumption in the face of uncertain incomes. Households dissave when they suffer an adverse shock and save more when they are favored with a positive shock. This paper has presented evidence to support this thesis among agricultural households in northern Nigeria. Data limitations preclude definitive conclusions. However, the results suggest that: (1) households reduce their saving by large amounts when they receive an adverse shock on their upland plots - a one standard deviation shock is associated with dissaving of over 15 percent of average Nigerian household income; (2) consumption smoothing is effected through adjustments in saving in assets not subject to diminishing returns; (3) a significant portion of this response is increased net sales of grain contingent upon the realization of an adverse shock; and (4) households forecast the receipt of near-future adverse shocks on upland plots and increase their current saving in anticipation of the realization of these shocks.

Households in northern Nigeria use their assets as buffer stocks as one component of an *ex-post* risk-coping strategy. The complementary mechanism is cross-sectional risk pooling. In Udry (1994), evidence is presented that credit *cum* insurance transactions are used to pool the idiosyncratic risks faced by households within a village, but that a fully Pareto efficient allocation of risk is not achieved. These households use their asset stocks to smooth over time the remaining idiosyncratic risk, and presumably transitory aggregate risk as well. Unfortunately, the short time period covered by the data makes it impossible to identify separately the effects of seasonality and aggregate shocks on saving. A more thorough investigation of the role of saving in households' strategies for coping with risk in northern Nigeria and Africa more generally will be possible when data become available from a broader cross-section (so that regional shocks can be identified) or from a longer panel.

Appendix: Ordinary Least Squares Estimates

[Put Tables A2, A3, A4 here. There is no Table A1]

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*. Department of Economics, Northwestern University, Evanston, IL 60208. Katherine Czukas provided valuable research assistance. I thank Joe Altonji, Paul Collier, Angus Deaton, Mark Gersovitz, Bo Honoré, Yoon Joo Lee, Barbara O'Brien, T.N. Srinivasan, John Strauss, Anand Swamy, Ann Velenchik, participants at several seminars and an anonymous referee for comments on earlier versions. I received valuable advice from the members and chairman of the Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, where I was a visiting Research Fellow. Able and dedicated research assistance in Nigeria was provided by Adex Adisa, Comfort Amos, Mary Arokoyo, Florence Bako, Christiana Chindo, Abdu Haruna, Haruna Mohammad, Ayuba Randa, and Yohanna Tanko. This paper was prepared under a cooperative agreement between the Institute for Policy Reform (IPR) and the Agency for International Development (AID), Cooperative Agreement No. PDC-0095-A-00-1126-00. Views expressed in this paper are those of the author and not necessarily those of IPR or AID. Financial support from the National Science Foundation is gratefully acknowledged.

1. See the review by Besley (1993). Deaton (1992a) provides the only previous attempt to address risk and saving in an African context. He applies methods suggested by Campbell (1987) to a three-year rolling panel from Côte d'Ivoire. He finds evidence that households save in anticipation of declines in income, but that the amount saved is difficult to reconcile with the permanent income hypothesis.

2. This paper, therefore, is closely related to the important work of Paxson [1992], which uses rainfall data to identify transitory income shocks affecting households, which are in turn used to measure the marginal propensity to save from transitory income.

3. This result stands in striking contrast to Rosenzweig and Wolpin (1993), who show that farmers in India use draft animals to smooth income shocks. As noted by Rosenzweig and Wolpin, it must be the case that Indian farmers, unlike their Nigerian counterparts, do not have access to remunerative alternative assets not subject to diminishing returns with which to facilitate income smoothing.

4. The size of the sample was kept small in an effort to reduce non-sampling error on matters that are

notoriously sensitive (most importantly, great care is required in collecting information on asset stocks). See Udry (1991) for further details on the study area and survey methodology.

5. If an adverse shock in period 1 lowers period 2's expected income, as well as period 1 income, then period 1 consumption should fall. Period 1 saving might fall or rise, depending upon the size of the effect of the shock on period 1 income.

6. The possibility of correlations over time is discussed in footnote 10 and in section 5.

7. A Goldfeld-Quandt test of the hypothesis that the variance is the same for observations in periods 1 and 2 yields a strongly significant F(182,182) test statistic with a value of 2.07. The FGLS estimates presented in Table 2 are based on the standard two-step procedure. In the first step, OLS residuals are used to estimate the standard deviation of the errors in the two periods. The second step is WLS using the inverses of these estimates as the weights. OLS estimates of this equation (and all others in the paper) can be found in the appendix.

8. The hypothesis that there are no household fixed effects cannot be rejected: the Hausman test statistic is $\chi^2(4)$ and has a value of only 1.086 ($p = 0.90$). The fixed effect and FGLS estimates of the relationship between saving and the receipt of adverse shocks are virtually identical.

9. The Nigerian currency is the Naira, which ranged in value from \$1 = N4 in February 1988 to \$1 = N7 in February 1989. Some of the saving over the survey period was seasonal. The data do not cover February-April, when dissaving is likely to occur. Nominal GNP per capita statistics are calculated from Summers and Heston (1991).

10. As discussed in section 1, it is possible that the relative timing of the receipt of random shocks and the realization of their effect on income is not consistent with that demanded by the theory. In order to test for this possibility, I re-estimate equation (1) permitting the coefficients on Z_{jt} to vary across the time periods. The hypothesis that the effect of idiosyncratic shocks on saving is constant across periods cannot be rejected - the Wald $\chi^2(2)$ test statistic is 3.86 ($p = 0.15$). When attention is limited to the effect of shocks on upland plots the Wald $\chi^2(1)$ test statistic becomes 3.71, near conventional

significance levels. Adverse shocks on upland plots have a stronger effect on saving in period 2 than in period 1, indicating that some of the effect of period 1 shocks may be realized in period 2 income.

11. Livestock account for 68 percent of the value of households' portfolios early in the harvest season, and 30 percent soon after harvest is completed. 2 percent of the value of portfolios is goods for trading; the remainder of the households' portfolios are held in the form of grain stocks. Virtually all of the value of livestock is in the form of cattle, sheep and goats.

12. The Wald test of their joint significance is $\chi^2(2)$ with a value of 2.02 ($p = 0.36$).

13. Despite the existence of active agricultural labor markets in these villages, there were no instances in the sample of labor being hired to care for animals. Presumably, this pattern results from the potential for moral hazard in the care of animals. In these villages, animals must be confined during the farming season to avoid crop damage, and therefore must be fed and watered using household labor for several months each year.

14. There is a large literature in agricultural economics concerning the optimum size of herds. McIntire, Bourzat and Pingali (1992) provide a survey. The conclusion of this literature is that there are initially increasing returns to herd size, but that diminishing returns set in rapidly, and that optimum herd sizes depend on household size, landholdings and
weather conditions.

15. Hays (1975) describes storage technology, which is based on in-room storage of dried, bagged grain.

16. This is a technological condition - the marginal product of labor increasing with the shock - which corresponds to the particular shocks studied here. For example: infestation of a plot with exceptionally virulent weeds increases the amount of time spent weeding; early season flooding often requires replanting; late season bird attacks require labor inputs to keep the flocks away; and insects are removed by hand.

17. See Rosett (1959) for the first formulation of a similar model in the case of a single cross-section.

The procedure I follow is to first censor all observed net grain purchases from below at zero (all $T_{jt} < 0$ are set to zero). The resulting fixed effect Tobit model is estimated using Honoré's (1992) trimmed least squares estimator for censored models with fixed effects. Second, all observed net grain purchases are censored from above at zero, and again the resulting fixed effect Tobit model is estimated. These two estimators, one for $T_{jt} \leq 0$ and the other for $T_{jt} \geq 0$, are reported in Table 6A. The household fixed effects are not estimated.

18. In contrast to the assumption maintained in Udry (1990, 1994).

19. Supposing that the PIH is correct so that all transitory shocks are saved, this and the results in Table 2 imply $\epsilon \approx$N1500. Stationarity may not be a bad approximation. Incomes grew in the early 1980s because of the adoption of maize as a primary crop, but the process was complete before this survey began (see Smith *et al.*, 1994).

TABLE 1

Descriptive Statistics

	Mean	Std. Dev.
Overall Saving (x N1000) (s_{jt})	2.75	14.13
Period = 1	0.77	8.27
Period = 2	5.42	17.82
Saving in grain and farm inputs (such as fertilizer)	0.99	1.14
Period = 1	-2.48	8.02
Period = 2	4.46	13.17
Saving in livestock	1.76	9.65
Period = 1	2.56	5.80
Period = 2	0.96	12.33
Saving in stocks of goods for trading	-0.01	0.49
Period = 1	-0.01	0.39
Period = 2	-0.01	0.56
Index of Adverse Idiosyncratic Shocks (Z_{jt}):		
On Upland Plots	1.88	7.92
Period = 1	3.06	10.85
Period = 2	0.70	2.33
On Lowland Plots	0.21	1.77
Period = 1	0.34	2.24
Period = 2	0.19	0.81
Household Characteristics (X_j):		
Wealth at the time the household was formed (x N10000)	8.60	114.11

Age of the household head	40.64	12.21
Number of wives	1.52	0.79
Number of males 10-60 in the household	2.53	1.57
Number of dependents	3.67	2.61
Presence of a member of the household with a special skill (dummy variable)	0.60	0.24
Upland land owned in hectares	3.24	4.69
Lowland land owned in hectares	0.44	1.04

Table 2

The Determinants of Saving

Cash Saving	Overall Saving			Grain Saving			Livestock Saving	
Variable	Parameter Estimate	t	Parameter Estimate	t	Parameter Estimate	t	Parameter Estimate	t
Intercept	-0.556	-0.25	-0.273	-0.13	-0.388	-0.26	-0.124	-0.55
Period = 2	-2.526	-1.80	2.017	1.63	-4.544	-4.57	0.345	2.65
Adverse Shocks:[a]								
On Upland Land	-0.197	-2.65	-0.271	-3.85	0.070	1.41	-0.033	-2.89
On Lowland Land	-0.156	-0.84	-0.181	-1.07	0.018	0.14	-0.003	-1.46
Village = 1	4.081	2.54	3.757	2.56	1.125	1.02	0.473	3.00
Village = 2	0.952	0.63	0.093	0.07	0.928	0.89	0.089	0.60
Village = 3	0.547	0.36	0.103	0.07	0.410	0.39	-0.108	-0.72
Past Wealth[b]	0.022	4.80	0.000	0.11	0.023	7.35	-0.000	-0.13
Age of Household Head	0.008	0.16	-0.060	-1.31	0.053	1.55	-0.005	-1.07
Number of Wives	-0.021	-0.02	-0.239	-0.28	0.159	0.25	0.015	0.17
Number of Males Aged 10-60	0.269	0.74	0.306	0.93	0.088	0.36	0.049	1.40
Number of Dependents	0.103	0.41	0.430	1.87	-0.260	-1.51	-0.020	-0.81
Household Member with a Special Skill	-0.580	-1.01	-0.702	-1.34	0.158	0.40	-0.050	-0.88
Upland Land Owned	-0.354	-1.93	-0.438	-2.52	0.094	0.77	0.019	0.88
Lowland Land Owned	0.282	0.42	0.637	0.99	-0.488	-1.09	-0.075	-0.95
Upland Land * Period=2	2.598	9.72	1.347	5.68	1.238	6.56	0.008	0.33
Lowland Land * Period=2	-2.795	-2.42	-0.781	-0.77	-1.965	-2.40	0.073	0.69

notes: These are FGLS estimates. OLS residuals are used to estimate the standard deviation of the errors in the two periods.

The inverses of these estimates are used as weights for WLS to yield the estimates reported in the Table. The dependent variable in the first column is the change in the value of household stocks of grain, farm inputs, livestock and goods for trading over each of the two periods. In the columns 2-4, the dependent variable is the change in the value of household stocks of the relevant asset over each of the two periods.

[a]Number of self-reported adverse shocks, weighted by plot size.

[b]At time of first marriage (x N10,000)

Table 3A
The Determinants of Grain Sales

	Net Purchasers ($T_{jt} \leq 0$)		Net Sellers ($T_{jt} \geq 0$)		Gross Sellers	
Variable	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Parameter	T-Ratio
Period = 1	3.532	0.39	-17.944	-1.02	-17.550	-1.25
Period = 2	99.107	1.49	-0.697	-0.10	-12.372	-0.79
Adverse Shocks: [a]						
On Upland Land	5.724	3.12	7.624	2.05	7.106	2.59
On Lowland Land	23.139	0.95	0.554	0.11	-8.042	-0.23
Upland Land * Period = 1	-39.531	-5.06	0.439	0.07	0.813	0.18
Upland Land * Period = 2	-44.938	-20.55	3.172	0.80	10.406	1.35
Lowland Land * Period = 1	83.132	5.72	12.905	0.60	13.797	0.58
Lowland Land * Period = 2	35.649	1.95	4.991	0.39	3.346	0.22

Table 3B
Optimally Combined Estimates of the Determinants of Net Grain Sales

Variable	Parameter Estimate	T-Ratio
Upland Shock	7.168	12.33
Lowland Shock	1.139	0.23

notes: The procedure I follow is to first censor all observed net grain purchases from below at zero (all $T_{jt} < 0$ are set to zero). The resulting fixed effect Tobit model is estimated using Honoré's (1992) trimmed least squares estimator for censored models with fixed effects and reported in the first column. Second, all observed net grain purchases are censored from above at zero, and again the resulting fixed effect Tobit model is estimated and reported in the second column. These two estimates are optimally combined as suggested by Hansen (1982) to yield the estimates reported in section B of the Table. The dependant variable in the third column is the sum of all sales of grain in each period, disregarding purchases.

[a]Number of self-reported adverse shocks, weighted by plot size

Table 4

Do Households Save in Anticipation of Shocks?

	The Determinants of: Overall Saving		Grain Saving	
Variable	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio
Intercept	-0.164	-0.07	0.146	0.07
Period = 2	-2.482	-1.77	2.073	1.68
Adverse Shocks: [a]				
On Upland Land	-0.209	-2.83	-0.285	-4.11
On Lowland Land	-2.288	-0.79	-2.797	-1.11
Village = 1	3.676	2.29	3.204	2.20
Village = 2	0.908	0.60	0.048	0.03
Village = 3	0.342	0.22	-0.106	-0.08
Past Wealth [b]	0.022	4.83	0.000	0.05
Age of Household Head	-0.002	-0.03	-0.068	-1.50
Number of Wives	0.252	0.27	0.083	0.10
Number of Males Aged 10-60	0.213	0.59	0.229	0.70
Number of Dependents	0.064	0.25	0.373	1.63
Household with Special Skill	-0.666	-1.16	-0.807	-1.56
Upland Land Owned	-0.473	-2.49	-0.588	-3.30
Lowland Land Owned	0.393	0.59	0.787	1.25
Upland Land * Period = 2	2.722	9.98	1.501	6.22
Lowland Land * Period = 2	-2.870	-2.50	-0.875	-0.87
Next Period Shocks:				
Future Upland Shock [c]	0.649	2.10	0.800	2.76
Future Lowland Shock [c]	-1.583	-0.43	-2.232	-0.68

notes: *n=392.* These are FGLS estimates. OLS residuals are used to estimate the standard deviation of the errors in the two periods. The inverses of these estimates are used as weights for WLS to yield the estimates reported in the Table. The dependent variables are, respectively, the change in the value of household liquid assets (grain, farm inputs, livestock, and goods for trading) and stocks of grain over each of the two periods.

[a]Number of self-reported adverse shocks, weighted by plot size

[b]At time of first marriage (x N10,000)

[c]Adverse shocks reported for period 2, but included in the equation determining period 1 saving.

Table A2

OLS Estimates of the Determinants of Saving

	Overall Saving		Grain Saving		Livestock Saving		Cash Saving	
Variable	Estimate	t	Estimate	t	Estimate	t	Estimate	t
Intercept	-1.408	-0.55	-0.727	-0.33	-0.555	-0.30	-0.114	-0.51
Period = 2	-2.431	-1.63	2.054	1.62	-4.488	-4.15	0.345	2.65
Adverse Shocks:[a]								
On Upland Land	-0.234	-2.46	-0.285	-3.50	0.052	0.75	-0.034	-3.06
On Lowland Land	-0.013	-0.61	-1.697	-0.95	0.384	0.25	-0.003	-1.51
Village =1	6.206	3.43	5.453	3.52	0.708	0.54	0.453	2.85
Village=2	1.128	0.66	0.256	0.17	0.855	0.69	0.095	0.63
Village = 3	0.735	0.43	0.114	0.08	0.647	0.52	-0.088	-0.58
Past Wealth[b]	0.017	3.22	0.001	0.19	0.016	4.21	-0.000	-0.10
Age of Household Head	0.015	0.27	-0.076	-1.59	0.092	2.25	-0.006	-1.14
Number of Wives	0.336	0.32	-0.121	-0.14	0.327	0.43	0.008	0.08
Number of Males Aged 10-60	0.287	0.71	0.467	1.34	-0.176	-0.60	0.048	1.35
Number of Dependents	0.029	0.10	0.483	2.00	-0.440	-2.14	-0.015	-0.61
Household with Special Skill	-0.845	-1.31	-0.737	-1.33	-0.105	-0.22	-0.050	-0.88
Upland Land Owned	-0.350	-1.48	-0.438	-2.18	0.100	0.58	0.018	0.89
Lowland Land Owned	0.238	0.27	0.517	0.69	-0.332	-0.52	-0.074	-0.97
Upland Land * Period=2	2.558	8.87	1.332	5.40	1.219	5.82	0.009	0.35
Lowland Land * Period =2	-2.825	-2.32	-0.793	-0.76	-1.981	-2.24	0.073	0.69

notes: The dependent variable in the first column is the change in the value of household stocks of grain, farm inputs, livestock and goods for trading over each of the two periods. In columns 2-4, the dependent variable is the change in the value of household stocks of the relevant asset over each of the two periods.

[a]Number of self-reported adverse shocks, weighted by plot size.

[b]At time of first marriage (xN10,000)

Table A3

OLS Fixed-Effect Estimates of the Determinants of Grain Sales

	Net Sales		Gross Sales	
Variable	Parameter Estimate	t	Parameter Estimate	t
Period = 1	0.878	0.19	-2.625	-0.77
Period = 2	8.789	1.91	1.744	0.51
Adverse Shocks on:[a]				
Upland Land	1.434	3.94	2.011	7.48
Lowland Land	4.862	0.72	2.933	0.59
Upland Land * Period = 1	-1.835	-1.88	0.180	0.25
Upland Land * Period = 2	-3.285	-3.85	0.690	1.10
Lowland Land * Period = 1	-0.807	-0.21	-3.186	-1.12
Lowland Land * Period = 2	2.833	0.74	-0.606	-0.21

[a]Number of self-reported adverse shocks, weighted by plot size.

Table A4
Do Households Save in Anticipation of Shocks?

OLS Estimates of the Determinants of Saving

	Overall Saving		Grain Saving	
Variable	Parameter Estimate	t	Parameter Estimate	t
Intercept	-1.143	-0.44	-0.446	-0.20
Period = 2	-2.357	-1.58	2.139	1.69
Adverse Shocks:[a]				
On Upland Land	-0.247	-2.58	-0.300	-3.67
On Lowland Land	-1.395	-0.49	-2.024	-0.83
Village =1	5.974	3.29	5.174	3.34
Village=2	1.088	0.63	0.220	0.15
Village = 3	0.584	0.34	-0.050	-0.03
Past Wealth[b]	0.017	3.20	0.001	0.16
Age of Household Head	0.008	0.15	-0.084	-1.75
Number of Wives	0.521	0.50	0.111	0.12
Number of Males Aged 10-60	0.247	0.60	0.421	1.21
Number of Dependents	0.005	0.02	0.450	1.85
Household with Special Skill	-0.907	-1.40	-0.812	-1.47
Upland Land Owned	-0.460	-1.86	-0.573	-2.72
Lowland Land Owned	0.325	0.37	0.628	0.84
Upland Land * Period =2	2.673	8.96	1.471	5.78
Lowland Land * Period =2	-2.898	-2.38	-0.881	-0.85
Next Period Adverse Shocks:[c]				
Future Upland Shock	0.607	1.50	0.729	2.11
Future Lowland Shock	-0.614	-0.15	-1.172	-0.33

notes: The dependent variables are, respectively, the change in the vale of household liquid assets (grain, farm inputs, livestock and goods for trading) and stocks of grain over each of the two periods.

[a]Number of self-reported adverse shocks, weighted by plot size.

[b]At time of first marriage (xN10,000)

[c]Adverse shocks reported for period 2, but included in the equation determining period 1 saving.