Risk, Production, and Saving:

Theory and Evidence from Indian Households

Jonathan Morduch

New York University

Original: November 1990
Substantial revision: March 1999

I am grateful to Anne Case, Lawrence Katz and Peter Timmer for advice and encouragement and for useful discussions with Anil Deolalikar, Madhur Gautam, Lawrence Summers, Thomas Walker and seminar participants at Boston College, Harvard, MIT, University of Pennsylvania, Princeton, Stanford, UCLA, UCSD, University of Virginia, Yale, and UC-Berkeley. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Gokhale Institute provided facilities in India, and ICRISAT generously let me use part of their village data set. Financial support was provided by the Alfred P. Sloan Foundation. All views and errors are my own. Correspondence: Jonathan.Morduch@nyu.edu.

Risk, Production, and Saving:

Theory and Evidence from Indian Households

Abstract

The presence of uncertainty has been cited to explain a broad range of institutional arrangements and behavior patterns in low-income countries. Still, there is great debate about the role of uncertainty in developing economies, and the empirical evidence offers little help in choosing sides. For example, econometric studies have found near risk neutral behavior in production, despite experimental evidence that the same households are at least moderately risk averse. These apparent conflicts are reconciled in a framework which jointly considers consumption and production under uncertainty. The framework shows that the ability to borrow to smooth consumption is critical in determining the effect of risk on production. Using an eight-year panel of Indian households, borrowing constraints in consumption-smoothing are found to be strongly related to asset position in villages with poorly developed financial institutions. These constraints are, in turn, found to reduce the adoption of risky new hybrids and to increase crop and plot diversification. The results support the hypothesis that when capital markets are imperfect, the presence of uncertainty forges a link between consumption and production decisions. The results also suggest that ignoring consumption-smoothing can lead to substantial under-estimates of attitudes toward risk.

JEL Codes: **????**

1. Introduction

The past decade has seen a revival of interest in the structural foundations of economic growth. In particular, economists have re-examined the ways that the distribution of income affects production choices – as mediated through imperfectly functioning capital markets, political institutions, and other central features of economies (e.g., Banerjee and Newman JPE 1993, Aghion-Howitt, Pikkety, Jovanovic-Greenwood, Bencivenga-Smith, Obstfeld, etc.)

But these propositions have been hard to test. The most important production choice for most American workers is the career choice, and this is made just once typically and risk aspects are hard to disentangle from others. The paper here exploits the unique position of farmers in the semi-arid tropics in predominantly rain-fed agriculture. Semi-arid tropics cuts across South India and across Africa in a narrow band from Nigeria east and then along the Eastern coast, south through Burkina Faso and Zimbabwe. What makes these households different from others is that important choices concerning the riskiness of production are made at the start of each season, in contrast to the relatively stability of production patterns in areas of assured rainfall or heavily irrigated areas. An eight-year panel of data is used from three villages in areas in which risk is a predominant concern and the distribution of income is wide.

Over the last four decades economists have taken great strides in characterizing the role of uncertainty. These advances have been particularly important for the understanding of developing economies. The existence of uncertainty, together with imperfect information, helps to explain a broad range of institutional arrangements and behavior patterns in low-income countries, and work in this spirit has laid the foundation for what has been called “the new development economics" (Stiglitz, 1986).[1] But while the theoretical tool kit has expanded, empirical findings on the role of uncertainty are mixed. In this study I attempt to reconcile apparent anomalies in the existing empirical literature by considering an integrated dynamic framework for analyzing consumption and production decisions under uncertainty. The analysis suggests that the role of uncertainty in production can depend critically on the ability to borrow to smooth consumption over time. This hypothesis is supported with evidence from an eight-year panel of farm households in three villages in South India. The framework draws from insights of macroeconomic work on intertemporal consumption patterns (e.g., Hall, 1978; Hayashi, 1987; Zeldes, 1989a), but it relaxes the assumption that income is exogenous to allow that households constrained in smoothing consumption will attempt to smooth their income. The study proceeds by estimating the effect of borrowing constraints on consumption patterns and relating these constraints to risky production choices.

The results here suggest that farmers use the available means to smooth consumption over time, but most are constrained in doing so. Groups with the weakest asset positions (laborers and small-scale farmers) appear to be the most liquidity constrained and large farmers appear to be unconstrained. Thus, even where informal institutions have arisen in the face of (formal) market imperfections, consumption-smoothing mechanisms do not meet the needs of all households. These empirical measures of borrowing constraints are found to have a positive but weak impact on crop diversification and a strong positive impact on spatial diversification of

[1] The role of uncertainty in developing economies is heightened because financial instruments often do not exist to effectively diffuse risk, and because agriculture usually accounts for much of employment. The joint occurrence of risk aversion and imperfect information can explain credit rationing, the under-provision of insurance, and tenurial arrangements, such as sharecropping contracts (Stiglitz, 1986). Behavioral responses to uncertainty have been seen in slow rates of technological adoption, intra-village exchanges, migration, fertility, and marital patterns (Feder, Just and Zilberman, 1985; Walker and Ryan, 1990; Rosenzweig and Stark, 1989; Rosenzweig, 1988; and the papers collected in Roumasset, Boussard and Singh, 1979, especially Hans Binswanger's overview, chapter 20).

plots. Evidence on the adoption of risky hybrids is mixed, but the preponderance of the data supports the view that those who are less able to compensate for shortfalls take greater precautions beforehand.

2. Risk in Rural Economies

The empirical evidence to date offers little help in choosing sides on the importance of risk in rural economies (Roumasset, Boussard and Singh, 1979). For example, experimental evidence on farmers' risk attitudes in central India indicate at least moderate risk aversion (Binswanger, 1981), while econometric evidence for the same samples show very small or insignificant effects of risk on observed production decisions (Binswanger, et al. 1982; Antle 1989). Citing the latter evidence, some observers argue that too much attention is paid to the role of risk. Rather, they argue that concern with expected profitability and other constraints far outweighs concern with uncertainty, even in samples in which risk might be expected to loom large, such as among subsistence farmers (Roumasset, 1976; Walker and Ryan, 1990). Other observers point to the cases in which risk appears to play a significant part in producers' decisions. These observers see a potential for improved efficiency and welfare through stabilization programs, disaster relief, futures markets and other programs which aid in softening the impact of bad shocks (Newbery and Stiglitz, 1981; Timmer, 1988).

Given its importance for policy design, it is not surprising that the role of risk has received so much attention. However, it is perhaps more surprising that although the interdependence of risk, production, and saving has been the focus of theoretical investigations (e.g., Banerjee and Newman, 1991, and Eswaran and Kotwal, 1989), by and large the empirical literatures on consumption and production remain independent. Work on consumption and saving has traditionally assumed that the distribution of expected income is exogenous, and work on risk-taking in production has ignored the role of consumption-smoothing.[2] While the separability assumptions have allowed a sharp focus on some questions, they have meant putting on blinders to potentially important linkages between consumption and production choices. These linkages arise when markets are imperfect (particularly capital markets), and they will be especially critical in developing economies. This is because, in addition to the extensiveness of market imperfections, most households are engaged in agriculture and are thus both producers and consumers.[3] Analyzing this dual role has been the goal of the emerging empirical literature on agricultural household models, but to date uncertainty has not been considered.[4] The present paper is a first step toward filling that gap.

While households may not be able to perfectly smooth consumption, they typically have a wide variety of mechanisms for reducing its variability. Common mechanisms include borrowing and saving, buying and selling assets, obtaining supplementary employment,

---

[2] While rural households make decisions from harvest to harvest and year to year, the bulk of econometric work on uncertainty and production focuses on decisions in a single period only. A typical approach in applied work is to estimate attitudes toward risk by regressing a measure of the extent of risky production activities (e.g., acreage allocated to a risky crop) on a matrix of variables that includes a measure of the volatility of expected outcomes (e.g., the sample variance of net revenues.) The coefficient on this proxy for "riskiness" is then taken as a measure of attitudes toward risk. The results rest on the assumption that households simply consume their net returns at the end of each period: consumption-smoothing is eliminated altogether. (The standard framework can be amended to allow households to save a fixed fraction of their income each period, but period to period consumption-smoothing cannot.)

[3] While the scenario is natural with regard to subsistence farmers, it also has analogues elsewhere. A similar interaction of liquidity constraints and financial decisions has been investigated by Hoshi, Kashyap and Scharfstein (1990) for corporations in Japan. [UPDATE; OBSTFELD]

[4] See Singh, Squire and Strauss (1986) for an overview. Rosenzweig and Wolpin (1993) consider a case in which non-separability arises because inputs used in production (bullocks) are also bought and sold to smooth consumption. The link between consumption and production is given by bullock availability, whereas in the framework described here, non-separability need not stem from constraints on production choices. While they do not explicitly consider borrowing constraints, Roe and Graham-Tamasi (1986) construct a dynamic household model similar in spirit to that here. Their focus is on the theoretical implications of multiplicative uncertainty, a case in which separability still holds. In studying sequential decision-making within a single year, Gautam (1989) considers non-separability in a sense close to that used here.

collecting insurance, obtaining gifts from friends and relatives, and/or receiving government transfers. This paper rests on the observation that if households know that these consumption-smoothing possibilities will exist *ex post* (albeit at some cost), then the ultimate "riskiness" of a given endeavor may be greatly reduced *ex ante*: a household can face a great deal of income variability but know that they will be exposed to little risk in terms of consumption. At the extreme, if a household is able to compensate perfectly for unfavorable outcomes after they occur, the household might choose to ignore the variability of income in favor of greater expected returns. In the standard empirical framework such a production pattern would be interpreted as indicating near risk neutral preferences, no matter what are the actual "deep" preferences of the household. In this case, measuring attitudes toward risk in the traditional fashion is not appropriate, and doing so will lead to a downward bias in estimates (since measures of income variability will exaggerate the impact on utility.)[5]

The importance of consumption-smoothing has been documented in a growing literature on saving in developing countries (Gersovitz , 1988; Deaton, 1990). Studies have found evidence consistent with the permanent income hypothesis (Bhalla, 1979; Wolpin, 1982; Paxson, 1992), but they have rested on the assumption that households are able to borrow and save freely. Angus Deaton (1989, 1990) has questioned this assumption and proposed instead a framework built on the observation that households frequently cannot borrow against future

[5] The results may still be good guides to assessing the ultimate role of uncertainty, but it will not be possible to identify the part played by preferences and that played by constraints. Furthermore, while pooling samples is frequently justified on the grounds of homogeneous preferences, the analysis here suggests that it is also necessary to assume homogeneous access to credit markets (and credit market substitutes). If the claim is violated, as is found in the sample used in this study, estimation will again result in downward biases. Perhaps most important, the lessons learned from individual studies will be institution-specific, and they will only be transferrable to contexts with similar capital markets. The evidence here suggests that there can be substantial variation in financial structure even between villages in similar agroclimatic zones.

income. Although the present study provides the first explicit tests of such borrowing constraints in a developing country sample (Gersovitz, 1988, p. 394; Deaton, 1990), there is ample descriptive evidence consistent with their existence. For example, using detailed data on financial transactions, Hans Binswanger, et al. (1985) find that imperfect information and lack of collateral are central characteristics of rural financial markets -- and that these are central in determining credit allocation.[6]

3. Data

The household data used in this study were collected by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) as part of their Village Level Studies program.[7] ICRISAT collected information on production, consumption, wealth, labor supply, demographics and climate for households in ten villages in rural India for up to ten years. Forty households were chosen and surveyed in each village. In terms of operated area, in each village approximately ten households are comprised of laborers, ten are small-scale farmers, ten are medium-scale and ten are large-scale. The data were collected at intervals of 20 to 40 days and then aggregated to form annual data.[8]

The sample used here includes data from three villages, each in a different agro-climatic

[6] Bhargava and Ravallion (1993), working with the same data used here, follow the framework of Hall (1978) and find evidence consistent with imperfect credit markets. However, because they do not formulate clear alternative hypotheses, their result may stem from rejection of the assumptions of rational expectations, perfect capital markets, and/or the quadratic form of utility.

[7] More detailed information on the data is available in R. P. Singh, et al. (1985) and Walker and Ryan (1990). Much of the information in this section comes from Walker and Ryan (1990), chapter 7.

[8] The sampling fractions for laborers is 7, 10, and 29 percent in Aurepalle, Shirapur and Kanzara, respectively. The sampling fractions for cultivators is 9, 16, and 28 percent. The sampling fractions for the total group is 8, 13, and 24 percent, respectively. Aurepalle is in western Andhra Pradesh, while the other two are in eastern districts of the state of Maharashtra.

region and having a different institutional structure, and the survey covers the eight years 1976-77 to 1983-84. The villages are very poor, even in the Indian context. Averaging over the three villages and across the time period, the annual per capita income was Rs. 700 in 1977 prices; this translates roughly into $80 (in 1977 prices) and was significantly less than the all-India average of Rs. 1080 (Walker and Ryan, 1990, p. 69). Tables 1, 2 and 3 present information on consumption, income and financial trans-actions in the three villages.[9] The villages' climatic situations are clearly reflected in the data.

Rainfall is highest and most assured in the village of Kanzara; as a consequence, crop income is substantially higher than in the other two villages.[10] Formal credit institutions have also made relatively large in-roads in Kanzara, largely because default risk there is lower for the banks. The volume of credit is roughly two thirds of that in the other two villages, however. This is most likely because a greater fraction of investment comes from equity, given the less risky environment. Only 4% of gross cropped area is irrigated, reflecting the assuredness of rainfall, and most of production is rainy-season cotton and sorghum.

In contrast, the village of Shirapur is the least prosperous agriculturally and has the lowest average rainfall; labor income, however, is an important supplement to crop income. Rainfall in Shirapur is also erratic, and dry years can mean drought and sometimes famine (although no famines occurred during the sample period). Soils in Shirapur are largely deep vertisols, however, which have high moisture retention capacity. As a consequence much of the planting is completed after the rainy-season, when the greatest source of uncertainty has been

[9] The data on consumption in Table 1 pertain to 1976-77 through 1981-82. While data on food consumption extends through 1983-84, evidence for the restricted sample is presented to allow comparisons.

[10] Average rainfall is 710 mm., 690 mm., and 820 mm. in Aurepalle, Shirapur and Kanzara, respectively.

resolved. About 14% of gross cropped area (GCA) is irrigated, and sorghum is the most important crop. Transfers are a relatively important source of income in Shirapur, and friends, relatives and other villagers provide about half of all loans. Due to a large number of defaults, institutional lending dried up during the period, but informal sources were able to mobilize a substantial amount of funds. Typically loans from the informal sector are short term and interest is not charged. This is not so in Aurepalle, where even loans from relatives must be repaid with interest (Walker and Ryan, p. 206).

Informal institutions also account for most of lending in the village of Aurepalle, although professional moneylenders have the most important role there. Annual average rainfall in Aurepalle is again quite low and variable; on average 21% of GCA is irrigated. Soils in Aurepalle are generally shallow and medium-deep, having low water-retention capacity; rainy-season sorghum, castor, pearl millet and rice are the major crops. Table 1 shows that, like rainfall, consumption in Aurepalle is relatively low and varying. The relatively high fraction of food in consumption (72%) suggests the greater prevalence of poverty in Aurepalle, compared with the other two villages.

Across the villages, labor income is an important supplement to farm income, although it falls off with land-holding class. The evidence suggests that informal institutions provide an important means of consumption smoothing, although the data do not reveal a clear story as to how effective they are; in Aurepalle and Shirapur, informal mechanisms account for three quarters of total lending in rupees. Across the villages, the coefficients of variation of consumption are uniformly lower than that of income (0.30, 0.21, 0.21 for Aurepalle, Shirapur, and Kanzara versus 0.34, 0.36, 0.25), but not overwhelmingly so. While there are a much higher number of credit transactions in Aurepalle and Shirapur than Kanzara, most loans are small consumption loans of between 50 and 100 rupees. In Aurepalle, interest rate as high as 25% for 3 to 4 months are typical, and default rates are roughly 1 in 20. Monitoring is close and payment is often in kind.

Econometric evidence on these general observations is presented below. The results there suggest that in Aurepalle and Shirapur, the traditional money-lending system provides a means for smoothing consumption over time, but it does not serve all economic strata of the village equally. Although all strata may have access to credit, the amount they can borrow against future income appears to be limited by their asset position.

4. Saving and Production with Borrowing Constraints

I begin with a model of intertemporal consumption smoothing with uncertain future income, but I depart from the standard setting by allowing households to affect the riskiness of production. This is modeled as a portfolio choice problem, where households allocate inputs to a safe and a risky production activity.[11] All production choices are made in period *t*, and net income Y_{t+1} is realized in period $t + 1$. Net income is thus a function of the share of inputs devoted to the risky activity, 2_t, and the outcome of uncertainty *ex post*, $:_{t+1}$: $Y_{t+1} = Y(2_t, :_{t+1})$. Shocks can be negative or positive, and they are normalized so that the riskiness of activities is described by the relationship that $MY_{t+1}/2_t \exists 0$ if $:_{t+1} \exists 0$ and $MY_{t+1}/2_t < 0$ if $:_{t+1} < 0$. Increasing risky activity raises income when shocks are good, but it reduces income when shocks are bad.

Lifetime utility is maximized in each period *t* by choosing the level of risk-taking in

[11] Other sorts of risk-taking can also be considered in this general setting. For example, instead of focusing on cropping patterns, risk-taking could take the form of choices over costly inputs, such as some forms of irrigation, which reduce losses in years of low rainfall but which make little impact in good years. The model can also accommodate uncertainty of both consumer and producer prices, with analogous interpretations and consequences. In order to simplify discussion, and because it is most relevant to the Indian case, I will focus on production, however.

production and the level of consumption versus saving:

$$\max_{\{\theta_t, C_t\}} E_t \sum_{k=0}^{T-t} \beta^{k+1} U(C_{t+k}) \tag{1}$$

$$\begin{aligned} s.t. A_{t+k} &= (A_{t+k-1} - C_{t+k-1})(1 + r_{t+k}) + Y_{t+k} \\ C_{t+k} &\geq 0 \text{ for } k = 0,1,...T-t \\ (A_{t+k} - C_{t+k}) &\geq 0 \text{ for } k = 0,1,...T-t-1 \\ A_T &\geq 0 \\ Y_{t+k} &= Y(\theta_{t+k-1}, \mu_{t+k}), \end{aligned}$$

where the utility function is additively separable and equation (2) shows that A_{t+1}, assets at the start of period $t+1$, grow with net savings balances $((A_t - C_t)(1 + r_{t+1}))$ and current income. The discount factor is $\exists$, and leisure is assumed to be separable from consumption in the utility function.

The condition that $(A_t - C_t) \exists 0$ in each period t means that consumption cannot exceed current assets: it is not possible to borrow against future income. Gersovitz (1988) describes other forms of borrowing constraints. The analysis will not be affected by assuming that net assets must always be larger than an arbitrary constant, on either side of zero. A potentially important related issue, which I have not treated, is that resources may be diverted from productive ends into forms suitable for collateral (e.g., into jewelry purchases). Households can still produce even when physical assets are drawn down to zero. This assumption reflects the inability to sell some productive assets (e.g., human capital and often land). Incorporating a more stringent bankruptcy condition will follow naturally from the framework above and will heighten the effect of borrowing constraints in inducing risk averse behavior. However, the assumption here seems the most appropriate characterization of agriculture in South India.

Optimal Consumption Behavior. While production choices are made before consumption, it is helpful to work backwards since production decisions are predicated on optimal consumption behavior. That behavior is formally similar to that for the standard case in which the distribution of expected income is exogenous (because at the time of the consumption decision, current income is given). Ths stochastic dynamic programming problem is analyzed via a straightforward application of Kuhn-Tucker conditions and the envelope theorem to yield the Euler equation

$$\begin{gathered} U'(C_t) = E_t(1+r_{t+1})\beta U'_{t+1}(C_{t+1}) + \lambda_t \\ (A_t - C_t) \geq 0 \text{ if } \lambda_t = 0 \\ (A_t - C_t) = 0 \text{ if } \lambda_t > 0 \end{gathered} \tag{2}$$

(see, e.g., Zeldes, 1989, and Browning and Lusardi, 1996).

Optimal Risk-Taking. Risk-taking in period *t-1* will depend on the expectation of constraints in period *t*. The household's problem is then to maximize lifetime utility as given by equation (1), taking into account optimal consumption behavior described above. By the envelope condition, the first order condition is that

$$E_{t-1} \frac{dV'_t(A_t(C_t^*))}{dX_{t-1}} = E_{t-1}\, U'(C_t^*) \frac{dZ_t}{dX_{t-1}} = 0, \tag{3}$$

After simplifying by using equation (5), the first order condition can be rewritten as:

$$E_{t-1}\left[\frac{1+r_{t+1}}{1+\delta} \frac{\partial V_{t+1}}{\partial A_{t+1}} \frac{\partial Z_t}{\partial X_{t-1}} \right] = -\, E_{t-1}\left[\lambda_t \frac{\partial Z_t}{\partial X_{t-1}} \right]$$

which can be expanded as

$$\sum_{i=1}^{n} p^i \, E_t \left[\frac{1+r_{t+1}}{1+\delta} \; \frac{\partial V^i_{t+1}}{\partial A^i_{t+1}} \; \frac{\partial Z^i_t}{\partial X_{t-1}} \right] = 0$$

if $\lambda^i_t = 0$ for all *i* when there are no borrowing constraints, and

$$\sum_{i=1}^{n} p^i \, E_t \left[\frac{1+r_{t+1}}{1+\delta} \; \frac{\partial V^i_{t+1}}{\partial A^i_{t+1}} \; \frac{\partial Z^i_t}{\partial X_{t-1}} \right] = - \sum_{i=1}^{n} p^i \, \lambda^i_t \; \frac{\partial Z^i_t}{\partial X_{t-1}} > 0 \tag{4}$$

if $\lambda^i_t > 0$ for all *i* when there are. Here $i = 1, 2, \ldots, n$ indicates the state of nature and p^i gives the probability that state *i* will occur. The equation shows that the household will determine the optimal amount of risk-taking based on expected lifetime utility (current utility enters implicitly through $C^*(A_t)$) balanced against the degree of expected borrowing constraints.

The impact on risk-taking of borrowing constraints in consumption-smoothing can be seen by comparing the case in which expected constraints are binding with that in which they are not. When households do not expect to face borrowing constraints, the right hand side will equal zero since λ_t will always be zero. However, when borrowing constraints are expected to bind, the right hand side of (4) will be positive.[12] As a consequence, the expected marginal benefit of risk taking must be greater in the constrained case -- and risk taking must then be lower.

Equation (4) shows that risk-taking will be determined by its effect on lifetime utility, not just on current income as commonly posited in econometric work. Moreover, the greater the expected borrowing constraints, the smaller will be the extent of risk-taking. Thus, production decisions do not just depend on attitudes toward risk: they also depend on how much risk must

[12] That the right hand side will be positive can be seen by partitioning the n states into two groups: good states and bad states. In the good states, borrowing will not be necessary and λ_t will equal zero. Thus the sign of the right hand side will be given by circumstances in the bad states. In the bad states, λ_t will be binding (and thus positive) and the marginal effect of risk-taking will be negative. This is by definition of risk-taking: i.e, that risky activities reduce income in bad times. Since the probability of a given state is always non-negative and the summed term is multiplied by negative one, the right hand side is positive.

be borne -- and this depends on the ability to borrow (and the cost of borrowing) when income is transitorily low. Accordingly, limitations on consumption-smoothing must be considered in explaining risk taking in production.

In order to test this prediction, it will be necessary to find an empirical measure of borrowing constraints; those constraints will then be related to risk-taking. The strategy is described explicitly in the next section.

5. Estimating the Degree of Borrowing Constraints

The empirical strategy proceeds in two steps. First, empirical measures of borrowing constraints in consumption-smoothing are found by exploiting information from constrained and unconstrained samples. Next, after correcting for measurement error and endogeneity, these estimates are used to explain risk-taking in production. A variety of measures of consumption and risk-taking are considered, as well as different samples.

Consumption-Smoothing and Liquidity Constraints

Evidence of liquidity constraints is found by parameterizing and estimating the equilibrium condition described by equation (2) of Section 3 above. Following Hall (1978), the joint assumptions of rational expectations and perfect capital markets imply that if borrowing constraints are not binding ($8_t = 0$), then all variables at time t which are not included in equation (8) should be orthogonal to the error term. But if $8_t>0$, the coefficient on the log of income should be negative when included since an increase in income is positively correlated with a loosening of the liquidity constraint.

While the condition given in equation (3) appears to be standard (as in Browning and

Lusardi, 1996), it differs in that expected income is endogenous. Accordingly, the incidence of credit market imperfections will be understated since potential constraints will be anticipated and partly offset by less risky production choices. Thus 8_t will be a downward-biased measure of access to credit markets, since those who cannot borrow to cover income shortfalls will be less willing to gamble with their income. At the extreme, a household that completely self-insures *ex ante* due to expected constraints *ex post*, may *appear* to be have no problem gaining access to credit when this is not the case at all. Still, since the test will be biased against finding liquidity constraints (compared with the case in which income is exogenous), the method can be revealing. The inter-relation of liquidity constraints and production decisions will raise methodological issues in the next section, however.

Following Hayashi (1985) and Zeldes (1989a), the sample is split into groups which are likely to be liquidity constrained and those which are not. The groups are split by the amount of land cultivated (none, small-scale, medium-scale and large-scale) in the year prior to the first year of the sample. An alternative specification explores the role of caste status. By focusing on changes in consumption, rather than a particular measure of financial saving, the approach allows for the roles of smoothing via in-kind transfers, purchases/sales of jewelry and productive assets and other widely used substitutes for financial saving (Walker and Jodha, 1986; Walker and Ryan, 1990).

Derivation of the Estimating Equation

[CONDENSE THE NEXT PAGE] In order to test the relationship described in equation (8), I assume that preferences can be described by a constant relative risk aversion utility function, with taste shifters θ_{it}.[13] The utility of household *i* at time *t* is thus:

$$U_{it} = U\left(\frac{C_{it}}{F_{it}};\theta_{it}\right) = \frac{\left(\frac{C_{it}}{F_{it}}\right)^{1-\alpha}}{1-\alpha}\exp\{\theta_{it}\} \tag{3}$$

where C_{it} = total household consumption,
F_{it} = adult equivalent family size,
θ_{it} = household-specific variables which affect tastes, and
α = the coefficient of relative risk aversion.

At this point, two features should be noted. First, the specification allows utility to reflect age, education, and other relevant variables:

$$\theta_{it} = b_0\, age_{it} + b_1\, age_{it}^2 + b_2\, education_{it} + \tau_i + \mu_t V_i + u_{it} \tag{4}$$

where τ_i is a fixed household effect, μ_t is a time effect common to all households in a given village, V_i is a village indicator (equal to one if the household resides in the village), and u_{it} is an unobservable component assumed to be orthogonal to the other variables.

Second, I assume that the family cares about adult equivalent consumption (C_{it}/F_{it}) rather than total consumption (C_{it}). This is a reasonable approximation of actual household choices (Deaton and Muellbauer (1980), chapter 8), and the results below which are based on it seem sensible. The equation which is ultimately estimated has consumption variables on the left hand side and family size variables on the right, however. Plausible estimates of α will generally support the approach taken, and α can be identified from the coefficient on changes in family size [INTUITION]. [14]

[13] Experimental evidence for the ICRISAT sample, presented by Binswanger (1981), lends support for this specification over the assumption of constant absolute risk aversion.

[14] The equations were also run using just the number of family members, and it made little difference to the results.

Taking the derivative of (9) with respect to C_{it} and substituting into the equilibrium condition (8) yields

$$\frac{C_{i,t+1}^{-\alpha} F_{i,t+1}^{\alpha-1} \exp\{\theta_{i,t+1}\}(1+r)}{C_{it}^{-\alpha} F_{it}^{\alpha-1} \exp\{\theta_{it}\}(1+\delta_i)}(1+\Phi_{it}) = 1+e_{i,t+1} \qquad (5)$$

where the rate of time preference, δ_i, is allowed to vary between families. I have normalized the Lagrange multiplier, so that it now equals $\Phi_{it} = \lambda_t/E_t[U'_{i,t+1}(1+r)/(1+\delta_i)]$. This term is nonstochastic at time t, of the same sign as λ_t, and equals zero when borrowing constraints are not binding ($\Phi_{it} > 0$ if binding). The expectations error is $e_{i,t+1}$, and, following the assumption of rational expectations, it is assumed to have mean zero and to be orthogonal to all variables known at time t. Taking logs and rearranging gives

$$\log\left(\frac{C_{i,t+1}}{C_{it}}\right) = \frac{(\alpha-1)}{\alpha}\log\left(\frac{F_{i,t+1}}{F_{it}}\right) + \frac{1}{\alpha}\{(\theta_{i,t+1}-\theta_{it}) - \log(1+\delta_i) + \log(1+r) + \log(1+\Phi_{it}) - \log(1+e_{i,t+1})\}. \qquad (6)$$

Using the fact that

$$(\theta_{i,t+1}-\theta_{it}) = (b_0+b_1) + 2b_1 age_{it} + (\mu_{t+1}-\mu_t)V_i + (u_{i,t+1}-u_{it}) \qquad (7)$$

and removing variables which are fixed through time (they are accounted for in the estimation via household fixed effects) leads to the equation:[15]

This equation is equivalent to that which would be derived instead from a specification in which it is total consumption which matters to the household and the log of adult equivalent family size enters as a utility shifter (i.e., added to the right hand side of equation (10)). In the first case the coefficient on the family size growth rate is solely a function of α, the risk parameter. In the second case, however, the coefficient equals b_3/α, where b_3 is the coefficient of the log of adult equivalent family size if it was added to equation (12). Under both specifications the coefficient on the family size growth rate should be positive, but in the specification used here it is solely a function of α. That said, estimating α is of only secondary importance in this study, and the issue will not be critical in what follows.

[15] I assume that the education of the household head is completed before the sample period; thus it subtracts out. I also use $b_0\,(age_{i,t+1} - age_{it}) = b_0$ and $b_1\,(age_{i,t+1}^2 - age_{it}^2) = b_1\,(1 + 2\,age_{it})$.

$$\log\left(\frac{C_{i,t+1}}{C_{it}}\right) = \frac{1}{\alpha}\text{household dummy}_i + \frac{(\alpha-1)}{\alpha}\log\left(\frac{F_{i,t+1}}{F_{it}}\right) + \frac{1}{\alpha}\{2\,b_1\,\text{age}_{it} + (\mu_{t+1} - \mu_t)V_i + (u_{i,t+1} - u_{it}) + \log(1+\Phi_{it}) - \log(1+e_{i,t+1})\}. \tag{8}$$

Finally, by adding village-specific time period dummies to account for common taste shifts $(\mu_{t+1} - \mu_t)V_i$ and expectations errors; assuming that the unconditional expectation of the household taste changes $(u_{i,t+1} - u_{i,t})$ is zero and that their distribution is stationary; and adding log income as the overidentifying restriction leads to the estimating equation:

$$\log\left(\frac{C_{i,t+1}}{C_{it}}\right) = \text{constant} + \text{household dummy}_i + \text{time dummy}_t + \frac{(\alpha-1)}{\alpha}\log\left(\frac{F_{i,t+1}}{F_{it}}\right) + \frac{2b_1}{\alpha}\text{age}_{it} + \Omega\log\text{income}_{it} + v_{it} \tag{9}$$

where $v_{it} = 1/\alpha\ \{\log(1 + \Phi_{it}) + (u_{i,t+1} - u_{i,t}) - (\log(1 + e_{i,t+1}) - E[-\log(1 + e_{i,t+1}]))\}$ $= 1/\alpha\ \log(1+ \Phi_{it}) + 1/\alpha\ w_{it}$. If borrowing constraints are not binding, the expected value of v_{it} is zero,[16] but generally $[\log(1 + \Phi_{it})]$ will also be a component of the error term. The interpretation of the rejection of the overidentifying restriction relies on the assumption that both the unobservable change in tastes and the expectations error component are orthogonal to all the included variables. Thus the coefficient on the log of income can be interpreted as a reflection of the measure of borrowing constraints. This follows from the observation that the log of income should not be significant if the liquidity constraint is not binding; its coefficient (Ω) will only be significant if it picks up the effects of the normalized Lagrange multiplier, Φ_{it}. The expected

[16] This can be seen by taking a second-order Taylor approximation of $\log(1 + e_{i,t+1})$, which yields $e_{i,t+1} - 1/2\ e_{i,t+1}^2$. Assuming that $e_{i,t+1}$ has mean zero, the conditional expectation is simply the conditional variance of e at time t: 1/2 $\sigma_{e;i,t+1}$. This approximation will hold exactly if $e_{i,t+1}$ is lognormally distributed (Zeldes (1989a)).

value of the coefficient will be:

$$E\,\Omega = \frac{1}{\alpha} R_{\log(1+\Phi),\log income} \qquad < 0 \; if \; \Phi_i > 0; \; = 0 \; if \; \Phi_i = 0,$$

where $R_{\log(1+\Phi),\log\text{ income}}$ would be the coefficient on the log of income from an auxiliary regression of log $(1 + \Phi_{it})$ on the included variables.[17] Because an increase in the log of income is negatively associated with a tightening of the constraint, the expected value of Ω is negative. Moreover, the expected value of Ω will decrease (become more negative) with increases in log $(1 + \Phi_{it})$.

Other Considerations

Changes in weather, prices and other covariate shocks are controlled for by the village time fixed effects. This has the consequence that only borrowing constraints that are reflected in responses to *idiosyncratic* income changes are captured. Thus the test here is quite stringent: there may be substantial income-smoothing in response to the inability to smooth away covariate shocks, and this will not be captured. [18]

Because heterogeneity in the forecast error is likely, heteroskedasticity is accounted for by calculating standard errors following White (1980). While the relatively high quality of the data set makes measurement error less of a problem than in other cases, it is possible that some error remains in the consumption and income variables. If the error process has a moving average component, there could be additional problems of serial correlation, and this has not been

---

[17] This is the standard omitted variables formulation. Again, I have assumed that the components of the error term (v_{it}), apart from log $(1 + \Phi_{it})$, are orthogonal to all of the included variables.

[18] While the formulation here differs from the related work of Townsend (1994) and Morduch (1991), the fixed time effects mean that the test here similarly centers on the ability to diversify idiosyncratic shocks. [FOLD IN ABOVE]

corrected.

I have implicitly assumed separability between choices of consumption and labor supply. This could be problematic if post-season employment is an important means of compensating for low income (Browning, Deaton and Irish, 1985; Mankiw, Rotemberg and Summers,1985).

As discussed above, the assumption of rational expectations may seem overly restrictive. If it is generally a poor characterization, the tests should fail for all groups, whether or not they are constrained. If it is a fair approximation, then the overidentifying restriction should only be rejected for the predicted groups and the results for the other group(s) should be sensible. Thus there is a basis for judging the plausibility of the expectations assumption.[19]

Finally, I have not treated consumer durables explicitly. Because durables provide consumption beyond a single period, this flow should be imputed and used to adjust the consumption figures. However, because I lack the detailed information necessary to calculate these imputations, I estimate the equations using two different consumption variables: total expenditure and expenditure exclusively on food. While the former includes durables, the latter is only a partial measure of consumption (and likely to be less variable than total consumption). The results using the two measure are quite similar, however, indicating that the issue is not critical. In the main text I focus on the results based on total food consumption only, since it has the advantage of being available for two more years than total consumption.

[19] It could be that the unconstrained group has rational expectations, while the constrained groups form expectations adaptively or myopically. This could explain the pattern of the sign and significance of the coefficient on log income across groups. However, the pattern of the magnitudes of the coefficients is less easy to explain without recourse to the liquidity constraint hypothesis. Thus, while the power of the tests might be weakened if expectations are not fully rational, the evidence should still be revealing.

Results

The results for the full sample strongly reflect the prediction that the overidentifying restriction would be violated for the groups with fewer assets (column 1 of Table 4). Only income of large-scale farmers does not help to explain consumption growth, again as predicted. While the age of the household head does not significantly affect consumption growth, family size does. The estimated coefficient of relative risk aversion (which is recovered from the coefficient on the growth of family size) equals 1.39; this is a plausible value, at the low end of the range of estimates obtained using U.S. data.[20] While this study is the first attempt to empirically measure borrowing constraints in a developing country sample, the results are in accord with evidence on financial markets in India (Binswanger, et al., 1985) and are similar to evidence from the U.S. (Zeldes, 1989a).

The results for Aurepalle and Shirapur are similar to those for the full sample. Again the coefficients on the log of income is negative and significant for all groups except large-scale farms. As discussed in Section 2, borrowing in both villages is channeled mainly through informal institutions. The evidence here suggests that despite a relatively large volume of lending, many households still appear to be constrained. Somewhat surprisingly, the evidence against borrowing constraints is not clear cut in Kanzara, where assets and incomes are higher and formal institutions provide most credit. While the overidentifying restriction cannot be statistically rejected for any group, the coefficients on income are of similar magnitudes to those of the other villages (or larger), except for the case of landless laborers. Thus, although the data are too noisy to come to sharp conclusions with regard to Kanzara, evidence for constraints may

[20] Other estimates are catalogued by Auerbach and Kotlikoff (1987), p. 50. They range from 0.5 to 4.0.

emerge with better measured data.[21]

These results are echoed in Table 5, which presents similar evidence in different groupings. In the groupings by land-holding class, small-scale farmers in Aurepalle and medium-scale farmers in Shirapur no longer appear to be constrained, however, and small-scale farmers in Kanzara do. Apart from these changes, the coefficients seem fairly robust to the sample choice.

If less noisy data from Kanzara turned out to show little evidence of constraints (as found by Townsend, 1994), the evidence could help to explain the anomaly discussed in the first section. In the ICRISAT sample, Hans Binswanger (1981) found that in experimental games all farmers were at least moderately risk averse, but John Antle (1989) was unable to find evidence of risk aversion in his Kanzara sample -- despite it being a generally risky environment (Walker and Ryan, 1990, chapter 8).[22] He thus concludes that attitudes at the population mean are best described by risk neutrality. The results here suggest a different interpretation of Antle's results. Since farmers in Kanzara would be able to borrow to make up for income shortfalls, they need not be as concerned with income variability. Thus they might be generally risk averse (as is found by Binswanger), but pay little attention to risk in practice (as is found by Antle).

The results so far are encouraging, and I will now focus attention exclusively on Aurepalle, where the production issues are most clear cut. But before turning to the

[21] While the number of observations is relatively large for a sample of this sort, the power of the tests is lower than this might suggest since the cross-section is small. However, the length along the time dimension allows fairly reliable estimates of household fixed effects.

[22] Antle's study is built on the assumption that farmers optimally manage their portfolios of productive activities. Accordingly, he uses changes in the moments of households' net returns distributions to draw inferences about risk attitudes. He finds partial Arrow-Pratt risk aversion coefficients of 1.11, 1.40, and -0.10 for Aurepalle, Shirapur and Kanzara, respectively. Asymptotic t-ratios were 3.53, 5.44 and -0.48. In contrast, Binswanger's study found no coefficients below 0.32 or above 1.74. Binswanger's results stem from experiments in which farmers were allowed to

determinants of risk-taking in Aurepalle, it should be asked if the results on consumption-smoothing there can be explained by the competing hypothesis that the groups which appear constrained are in fact just displaying "rule of thumb" savings behavior (i.e., they just consume a fixed fraction of their income each period.) In order to gauge the impact of this hypothesis, the Aurepalle sample was split into a group which included periods with above average income and a group in which it was below. If "rule of thumb" behavior characterizes consumption patterns, the coefficients on the log of income should be negative, significant and roughly the same size in both samples. If the borrowing constraint hypothesis is most appropriate, then the coefficients should not be significant in the sample of high-income periods, and they should be negative and significant in the other sample.

As seen in Table 6, the results for Aurepalle are consistent with the borrowing constraint hypothesis. The coefficients on the log of income for the two lowest groups are larger for the low-income sample, as expected. Somewhat curiously, the coefficient on the log of income for the medium-scale farmers is no longer significant. However, none of the income coefficients for the high-income sample are significant, suggesting that "rule of thumb" explanations are not appropriate in this context.

As described in the previous section (equation 16), an empirical measure of liquidity constraints in Aurepalle can be found by re-running the high-income sample without the income variables. The coefficients from that regression will be consistent estimates of the true population parameters, and they can be used to find noisy estimates of borrowing constraints for each household. After correcting for endogeneity and measurement error, this estimate can then

---

choose over lotteries in which the payouts were fractions of a day's wage -- and the farmers kept the proceeds.

be related to risky production choices.

6. Borrowing Constraints and Production

In order to determine the relationship of consumption-smoothing and risk-taking, it is necessary to construct a variable, $f(\Phi_{it})$, which captures expected borrowing constraints. An estimate of log $(1 + \Phi_{it})$ can be found by using the estimated coefficients from samples in which borrowing constraints do not appear to be binding: these coefficients are used to form an estimate of optimal consumption growth without constraints, and the difference between this measure and actual consumption growth is calculated:

$$f(\Phi_{it}) = 1/\alpha \ \ln(1+\Phi_{it}) + 1/\alpha \ w_{it} = \ln\left(\frac{C_{i,t+1}}{C_{it}}\right) - \ln\left(\frac{C_{i,t+1}}{C_{it}}\right)\Big|_{\Phi_{it}=0} \qquad (16)$$

As seen from equation (16), the result is a noisy measure of log $(1 + \Phi_{it})$, but the noisy elements should have zero mean and should be orthogonal to log $(1 + \Phi_{it})$. This presents a standard problem of error in the variable, and it is addressed by using instruments for the borrowing constraints.

These estimates are then related to risky production decisions. Two decisions are highlighted. The first is the choice between growing rainy-season castor or local cereal/pulse intercrops in Aurepalle. The second is the choice between high yielding varieties of rice (paddy) and traditional varieties, again in Aurepalle, where risk arises from potential failures of electric pumps in the post-rainy season. In both choices, the first option is both riskier and more profitable. These decisions were selected as they are among the few cases in which one choice does not dominate the other under most circumstances (Walker and Ryan, 1990, ch. 8). That is, the choices truly depend on preferences for risk versus expected profitability.[23]

The effect of liquidity constraints on production decisions is found by regressing the share of land allocated to the riskier option, X, on a matrix of household and farm characteristics, H, and the measure of borrowing constraints described above:

$$X = \beta \; f(\Phi) + \gamma \; H + u. \qquad (17)$$

Since there is likely to be a causal relationship between *ex post* liquidity constraints and cropping patterns (the more risky is the cropping pattern, the more likely are liquidity constraints), two steps were taken to modify the equation. First, rather than using the current measure of constraints, the average over the sample is used. And, second, the model is tested using instrumental variables for the liquidity constraint. As mentioned above, the use of instrumental variables also addresses the problem of error in the variable. The instruments are initial holdings of jewelry, consumer durables, buildings, stocks and land. Initial holdings are used since current holdings may be endogenous as well if they are bought and sold to smooth consumption.

The equations which are estimated account for land quality, family size, age, education, and fixed time effects -- as well as expected borrowing constraints. The fixed time effects capture changes in prices, weather patterns, and other shocks which are common to the village. The relationship between the measure of borrowing constraints and allocations to the riskier crop systems should be negative. The less it is possible to smooth consumption by borrowing, the more appealing it will be to reduce risk.

I also use the same explanatory variables to investigate the sources of crop diversification

[23] A third possible choice for investigation was that between high yielding varieties of sorghum and local cotton intercrops in Kanzara. However, it was excluded from the present study because I did not find clear evidence of liquidity constraints there.

and the spatial diversification of plots. Crop diversification is a widespread means of spreading risk, and plot diversification is particularly prevalent in dryland agriculture (Heston and Kumar, 1983). Plot diversification reflects an attempt to exploit the spatial variability of soil quality and climate as a risk-reducing mechanism. Thus the plot diversification index employed captures the number and relative size of a household's plots. Here, the measure of borrowing constraints should take a positive sign since these activities are risk-reducing.

Results

The results of that exercise are seen in Table 7. In four of the five tests, the measure of borrowing constraints took the expected sign and was significant at least at the 10% level. Households which expect to face borrowing constraints are both more likely to diversify their crops and to use a more scattered array of plots. In addition, they are less likely to substitute risky castor for the traditional sorghum intercrop, and they are less likely to grow new varieties of rice which have been identified as being more risky than traditional strains. In the case in which the sign was not as predicted (choice of HYV over traditional castor), the coefficient is not significantly different from zero.

While the choice of dependent variables was made partly to reduce confusion of the effects of borrowing constraints with returns to scale (the technologies investigated are highly divisible), issues of size will be important in other contexts. Similarly, the cases examined minimize the likelihood that the inability to obtain consumption loans is confused with the inability to obtain production loans. First, evidence suggests that production loans are more readily available than consumption loans. Second, with the exception of HYV rice, for which electric generators are required, none of the choices here involve significantly greater outlays than the others (Walker and Ryan, 1990).

While the results are consistent with the hypothesized linkages between consumption and production choices, the evidence should be interpreted cautiously. The evidence pertains to a group of decisions which have been particularly associated with risk-taking, and, while the data is of relatively high quality, the sample is small.

7. Conclusion

While risk is frequently cited as a critical feature of many economies, especially in low income countries, there is debate about its impact on decision-making. Roumasset (1976), for example, finds little impact of risk on production decisions. Rather, he argues that farmers are generally so constrained by technical factors, such as the quality of their land and the timing of rainfall, that they have little room to maneuver with regard to risk. This position is given support by studies which have found that many households appear to be risk neutral.

The conclusions of the present study are both at odds and in line with that view. They are consistent with the view by providing an additional reason why risk may not often matter. The reason does not hinge on technical constraints nor on assumptions about attitudes. Rather, it highlights possibilities for consumption-smoothing as a critical factor in risk-taking. Households that have greater access to credit markets (or substitutes for them), will in general be hit less hard by unfavorable states of nature. In bad times, they will be able to borrow against future income. Thus, while they might appear to have attitudes which exhibit a small degree of risk aversion, in fact their behavior may be mostly determined by consumption-smoothing possibilities.

The evidence in the paper is also at odds with the school which downplays the role of risk, since it is found that when borrowing constraints are binding, households are less likely to undertake risky activities. Borrowing constraints were found to be significantly related to the decision to diversify crops and plots, and they were found to negatively affect decisions to change from traditional cropping patterns to riskier plants.

The role of uncertainty has long been an important topic on the development economics agenda. This study represents a first step toward integrating the literatures on consumption, production and uncertainty in empirical work. This framework helps to explain anomalies in the current econometric literature on production and uncertainty, and it suggests that the role of uncertainty on risky investment behavior is bound up with the ability to smooth consumption.

Appendix

Data Definitions

Total Consumption - the sum of expenditure on the aggregated food variables (cereals, pulses, other food) and non-food expenditure, deflated by the village-specific CPI.

Food Consumption - the sum of expenditures on cereals, pulses and other food, deflated by the village-specific CPI.

Adult Equivalent Family Size - Adult equivalence was approximated following values estimated by Angus Deaton for a similar period in rural Sri Lanka (*Three Essays on a Sri Lanka Household Survey* LSMS Working Paper 11, The World Bank, 1981). The adjustment corrects for returns to scale of having both more children and more adults. No adjustments have been made for sex.

Age - the age of the household head.

Education - the total number of years of school attended by the household head.

Total Income - the sum of income from agriculture, labor, trade and handicrafts and net transfers, deflated by the village-specific CPI.

Total Assets - the value of owned area, livestock, implements, buildings, stocks, consumer durables, jewelry and net financial assets.

Crop Diversification Index - a Simpson index of diversity, calculated as one minus the sum of the squared proportional area allocated to each crop (proportional to gross cropped area). The index is zero in the case in which a farmer plants only one crop, and it approaches one in the case of perfect diversification. See T. S. Walker, R. P. Singh and N. S. Jodha, "Dimensions of Farm-Level Diversification in the Semi-Arid Tropics of Rural South India," ICRISAT, June 1983.

Plot Diversification Index - calculated as above, except that the index concerns the number and size of fields as a fraction of total area.

Crop shares - calculated as fractions of gross cropped area.

Soil Quality - acreage of deep, shallow or poor soil as a fraction of total area in the given season.

References

Antle, John (1989) “Nonstructural Risk Attitude Estimation,” *American Journal of Agricultural Economics* 71 (3): 774 - 784.

Auerbach, Alan J. and Laurence J. Kotlikoff (1987) *Dynamic Fiscal Policy*. Cambridge: Cambridge University Press.

Banerjee, Abhijit and Andrew Newman (1991), “Risk-bearing and the Theory of Income Distribution", *Review of Economic Studies* 58, 211 - 235.

Bhalla, Surjit (1979) “Measurement Errors and the Permanent Income Hypothesis: Evidence from Rural India,” *American Economic Review* 63: 295 -307.

Bhargava, Alok and Martin Ravallion (1993) “Is Household Consumption a Martingale? Tests for Rural South India,” *Review of Economics and Statistics.*

Bhende, M. J. (1986) “Credit Markets in Rural South India," *Economic and Political Weekly* XI (38-39) September 20 - 27.

Binswanger, Hans (1981) “Attitudes Toward Risk: Theoretical Implications of an Experiment in Rural India," *Economic Journal* 91: 867 - 890.

Binswanger, Hans, T. Balaramaiah, V. Bashkar Rao, M. J. Bhende and K. V. Kashirsagar (1985) “Credit markets in Rural South India,” Report No. ARU 45, Agriculture and Rural Development Department, The World Bank.

Binswanger, Hans P. and Donald A. Sillers (1983) “Risk Aversion and Credit Constraints in Farmers' Decision-Making: A Reinterpretation,” *Journal of Development Studies* 20 (1): 5 - 21.

Blanchard, Olivier and Stanley Fischer (1989). *Lectures on Macroeconomics*. Cambridge: MIT Press.

Bliss, Christopher and Nicholas Stern (1982) *Palanpur: The Economy of an Indian Village*. Oxford: Clarendon Press.

Browning, Martin, Angus Deaton and Margaret Irish (1985) “A Profitable Approach to Labor Supply and Commodity Demands over the Life-Cycle,” *Econometrica* 53 (3).

Chaudhuri, Paxson XXX

Chaudhuri, Ravallion XXX

Deaton, Angus (1990) “Saving in Developing Countries: Theory and Review,” *World Bank*

Economic Review.

Deaton, Angus (1989) "Saving and Liquidity Constraints," *Econometrica* 59, 1221-48.

Deaton, Angus and John Muellbauer (1980) *Economics and Consumer Behavior*. Cambridge: Cambridge University Press.

Eswaran, Mukesh and Ashok Kotwal (1989), "Credit as Insurance in Agrarian Economies," *Journal of Development Economics* 31: 37 - 53.

Feder, Gershon, Richard Just and David Zilberman (1985) "Adoption of Agricultural Innovations in Developing Countries: A Survey," *Economic Development and Cultural Change* 33 (2): 255 - 298.

Fetzer, James (1995), "Price versus Quantity Rationing: Identifying the Form of Borrowing Constraints in a Developing Country," Boston College, Dept. of Economics, working paper.

Gautam, Madhur (1990) "Sequential Decision-Making Under Temporal Risk by Households in Dryland Agriculture," Ph. D. Dissertation (in progress). Department of Agricultural and Resource Economics. University of Maryland.

Gersovitz, Mark (1988) "Saving and Development," Chapter 10 in H. Chenery and T. N. Srinivasan, eds., *Handbook of Development Economics*. Holland: Elsevier.

Jodha, N. S. (1981) "Role of Credit in Farmers' Adjustment against Risk in Arid and Semi-Arid Tropical Areas of India," *Economic and Political Weekly* XVI (42-43): 17-24.

Hall, Robert E. (1978) "Stochastic Implications of the Life Cycle - Permanent Income Hypothesis: Theory and Evidence," *Journal of Political Economy* 86: 971 - 987.

Hall, Robert E. and Frederic Mishkin (1982) "The Sensitivity of Consumption to Transitory Income: Estimates from Panel Data on Households," *Econometrica* 50: 461 - 481.

Hayashi, Fumio (1987) "Tests for Liquidity Constraints: A Critical Survey and Some New Observations," Chapter 13 in Truman Bewley, ed., *Advances in Econometrics: Fifth World Congress*, Volume II. New York: Cambridge University Press.

Heston, Alan and Dharma Kumar (1983) "The Persistence of Land Fragmentation in Peasant Agriculture: An Analysis of South Asian Cases," *Explorations in Economic History* 20: 199-220.

Hoshi, Takeo, Anil Kashyap and David Scharfstein (1991), "Corporate Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups," *Quarterly Journal of Economics* 106 (1), February, 33 - 60.

Mankiw, N. Gregory, Julio Rotemberg and Lawrence Summers (1985) "Intertemporal Substitution in Macroeconomics," *Quarterly Journal of Economics* 100 (Feb.): 225 - 251.

Morduch, Jonathan (1991) "Consumption Smoothing Across Space: Tests for Village-Level Responses to Risk," Harvard University (draft).

Newbery, David M. G. and Joseph E. Stiglitz (1981). *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk*. Oxford: Clarendon Press.

Paxson, Christina (1992) "Using Weather Variability to Estimate the Response of Savings to Transitory Income in Thailand," *American Economic Review* 82(1) (March): 15 - 33.

Roe, Terry and Theodore Graham-Tamasi (1986) "Yield Risk in a Dynamic Model of the Agricultural Household," Chapter 9 in Singh, Squire and Strauss (1986).

Rosenzweig, Mark (1988) "Risk, Implicit Contracts and the Family in Rural Areas of Low-Income Countries," *Economic Journal* 98 (December): 1148 - 1170.

Rosenzweig, Mark and Hans Binswanger (1993) "Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments," *Economic Journal* 103, January, 56 – 78.

Rosenzweig, Mark and Oded Stark (1989) "Consumption Smoothing, Migration and Marriage," *Journal of Political Economy* 97 (August).

Rosenzweig, Mark and Kenneth Wolpin (1993) "Credit Market Constraints, Consumption Smoothing and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India," *Journal of Political Economy* 101 (2), April, 223 – 244.

Roumasset, James A. (1976) *Rice and Risk: Decision Making among Low-Income Farmers*. Amsterdam: North-Holland.

Roumasset, James A., Jean-Marc Boussard, and Inderjit Singh (1979) *Risk, Uncertainty and Agricultural Development*. New York: Agricultural Development Council and Southeast Asian Regional Center for Graduate Study and Research in Agriculture.

Singh, Inderjit, Lyn Squire and John Strauss (1986) *Agricultural Household Models: Extensions, Application and Policy*. Baltimore: Johns Hopkins/The World Bank.

Singh, R. P., N. S. Jodha and H. P. Binswanger, (1985) *Manual of Instructions for Investigators in ICRISAT's Village Level Studies*. Resource Management Program, International Crops Research Institute for the Semi-Arid Tropics, Andhra Pradesh, India.

Stiglitz, Joseph E. (1986) "The New Development Economics," *World Development* 14(2): 257-

265.

Timmer, C. Peter (1988) “Agricultural Prices and Stabilization Policy,” Harvard University (draft).

Townsend, Robert (1994) “Risk and Insurance in Village India,” *Econometrica* 62, May, 539-592.

Walker, Thomas S. and James G. Ryan. (1990) *Village and Household Economies in India's Semi-Arid Tropics*. Baltimore: Johns Hopkins.

White, Halbert (1980) “A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity,” *Econometrica* 48: 817 - 838.

Wolpin, Kenneth (1982) “A New Test of the Permanent Income Hypothesis: the Impact of Weather on the Income and Consumption of Farm Households in India,” *International Economic Review* 23: 583 - 594.

Zeldes, Stephen P. (1989a) “Consumption and Liquidity Constraints: An Empirical Investigation,” *Journal of Political Economy* 97, No. 2 (April): 305 - 346.

Zeldes, Stephen P. (1989b) “Optimal Consumption with Stochastic Income: Deviations from Certainty Equivalence,” *Quarterly Journal of Economics*.

Table 1

Average Household Consumption Expenditure

1976-77 to 1981-82 (1976 Rupees)

	Aurepalle	Shirapur	Kanzara	Landless Labor	Small Farms	Medium Farms	Large Farms
Average per Household							
Total Consumption	2171.7	3048.5	3295.7	1869.8	2498.3	2585.0	4012.6
Food	1482.7	1980.1	1993.8	1267.5	1631.3	1677.2	2477.5
Average per Adult Equivalent Member							
Total Consumption	456.8	606.0	647.2	457.8	554.9	505.9	704.9
Food	312.9	394.5	395.0	310.4	362.1	325.8	439.4
Share of Food in Consumption	0.72	0.66	0.63	0.70	0.67	0.67	0.65
Household Members	5.5	6.0	6.2	4.6	5.4	6.2	7.3
Number of Households	33	36	36	21	33	21	32

NOTES: Six-year averages are calculated for each household and then averaged by village and land-holding group.

Table 2

Average Household Income

1976-77 to 1981-82 (1976 Rupees)

Variable	Aurepalle	Shirapur	Kanzara	Landless Labor	Small Farms	Medium Farms	Large Farms
Household Averages of Income							
Crops	1704.4	1753.2	2501.2	229.6	751.2	1162.7	4962.1
Livestock	985.9	563.6	749.8	134.3	183.9	464.2	1973.4
Trade & Handicrafts	534.7	19.9	150.4	175.9	313.6	477.8	24.1
Labor	474.9	1042.4	1530.9	1109.9	183.9	880.3	813.3
Transfers	-12.2	49.5	102.1	157.5	1.6	97.3	-11.7
Total	3687.8	3428.8	5034.8	2004.7	2506.8	3082.4	7760.9
Average Share of Total Household Income							
Crops	0.29	0.37	0.37	0.08	0.26	0.34	0.61
Livestock	0.15	0.16	0.10	0.06	0.08	0.15	0.24
Trade & Handicrafts	0.22	0.01	0.03	0.07	0.13	0.17	0.00
Labor	0.32	0.41	0.46	0.71	0.50	0.32	0.14
Transfers	0.02	0.06	0.03	0.09	0.03	0.02	0.00
Number of Households	35	36	36	21	33	21	32

NOTES: Six-year averages are calculated for each household and then averaged by village and land-holding group. Thus the sum of the averages of the components of income do not necessarily sum to that of total income.

Table 3

Credit Market Transactions

Number of Loans Taken by Sector, Source and Village
Aurepalle, Shirapur and Kanzara, 1976-77 to 1984-85

Sector and Source	Aurepalle No.	Aurepalle Percent	Shirapur No.	Shirapur Percent	Kanzara No.	Kanzara Percent
Formal Institutions	43	(26.4)	75	(23.0)	317	(69.0)
Government	5	(0.7)	12	(0.5)	23	(7.7)
Commercial Bank	18	(8.4)	5	(2.1)	27	(22.8)
Cooperative	20	(17.3)	58	(20.4)	267	(38.5)
Informal Institutions	1419	(73.6)	1130	(77.0)	478	(31.0)
Moneylenders	960	(52.5)	181	(18.5)	60	(6.7)
Relatives	77	(8.8)	184	(14.3)	33	(3.2)
Friends	3	(0.1)	399	(26.6)	16	(1.6)
Landlords	0	(0.0)	30	(1.0)	3	(0.1)
Employers	119	(4.3)	12	(0.1)	10	(1.5)
Tenants	5	(1.2)	28	(3.9)	0	(0.0)
Private Shop Owners	143	(5.2)	58	(1.6)	35	(2.0)
Other Villagers	112	(1.5)	238	(11.1)	321	(15.9)
Total Loans	1462		1205		795	
Total Amount in Rupees	536,443		535,465		356,903	

Source: Walker and Ryan (1990), Table 7.2. Cooperatives include Primary Agricultural Cooperative Credit Societies and Land Development Banks. The percent of total lending (in rupees) is given in parentheses.

Table 4

Village Samples

Euler Equation Estimates
Dependent Variable: Growth of Food Consumption$_{t,t+1}$
1976-77 to 1983-84

Independent Variable	Full Sample	Aurepalle	Shirapur	Kanzara
Log Total Laborer Income$_t$	-0.41* (3.18)	-0.17* (1.96)	-0.66* (3.80)	-0.08 (0.74)
Log Total Small Farm Income$_t$	-0.21* (2.63)	-0.16* (1.72)	-0.26* (1.66)	-0.22 (1.51)
Log Total Med. Farm Income$_t$	-0.11* (2.64)	-0.09* (1.72)	-0.11 (1.48)	-0.12 (1.04)
Log Total Large Farm Income$_t$	-0.02 (0.24)	0.04 (0.44)	0.01 (0.12)	-0.22 (1.38)
Growth of Adult Equivalent Family Size$_{t,t+1}$	0.28* (4.03)	0.32* (3.41)	0.15 (0.81)	0.28* (2.58)
Age of Household Head$_t$	-0.01 (0.89)	-0.00 (0.04)	0.00 (0.21)	-0.08* (2.92)
Adjusted R^2	0.32	0.32	0.37	0.30
Degrees of Freedom	660	216	215	215
Estimated Coefficient of Relative Risk Aversion	1.39*	1.47*	1.18	1.39*

NOTES: Equations are estimated with household and time fixed effects. Absolute values of t-statistics are in parentheses. See Appendix for data definitions. Asterisk indicates significance at the 5% level in the one-sided t-test.

TABLE 5

Landholding Groups

Euler Equation Estimates
Dependent Variable: Growth of Food Consumption$_{t,t+1}$
1976-77 to 1983-84

Independent Variable	Landless Labor	Small Farms	Medium Farms	Large Farms
Log Aurepalle Income$_t$	-0.18*	-0.11	-0.13*	-0.06
	(2.24)	(1.17)	(2.29)	(0.57)
Log Shirapur Income$_t$	-0.61*	-0.25*	-0.11	-0.06
	(3.43)	(1.71)	(1.39)	(0.75)
Log Kanzara Income$_t$	-0.12	-0.27*	-0.21	-0.12
	(1.11)	(1.65)	(1.59)	(0.73)
Growth of Family Size$_{t,t+1}$	0.21*	0.15	0.18	0.55*
	(2.18)	(1.05)	(1.40)	(3.71)
Age of Household Head$_t$	-0.06*	-0.03	0.00	-0.01
	(2.96)	(1.00)	(0.51)	(0.34)
Adjusted R^2	0.45	0.24	0.44	0.27
Degrees of Freedom	149	178	107	175
Estimated Coefficient of Relative Risk Aversion	1.27*	1.18	1.22	2.22*

NOTES: Equations are estimated with household and time fixed effects. Absolute values of t-statistics are in parentheses. See Appendix for data definitions. Asterisk indicates significance at the 5% level in the one-sided t-test.

TABLE 6

Aurepalle Consumption Equations

Euler Equation Estimates
Dependent Variable: Growth of Food Consumption$_{t,t+1}$
1976-77 to 1983-84

	Below Average Income	Above Average Income
Log Total Laborer Income$_t$	-0.37*	-0.16
	(2.59)	(0.52)
Log Total Small Farm Income$_t$	-0.45*	-0.01
	(2.23)	(0.04)
Log Total Medium Farm Income$_t$	0.04	-0.07
	(0.60)	(0.19)
Log Total Large Farm Income$_t$	0.11	-0.02
	(0.73)	(0.08)
Growth of Adult Equivalent Family Size$_{t,t+1}$	0.36*	0.39*
	(2.15)	(3.36)
Age of Household Head$_t$	-0.08*	-0.07*
	(3.51)	(4.00)
Adjusted R^2	0.21	0.38
Degrees of Freedom	70	71
Estimated Coefficient of Relative Risk Aversion	1.56*	1.64*

NOTES: Income is "below average" if it is more than 5% below the household mean. It is "above average" if it is more than 5% above. Equations are estimated with household and time fixed effects. Absolute values of t-statistics are in parentheses. See Appendix for data definitions. Asterisk indicates significance at the 5% level in the one-sided t-test.

TABLE 7

The Effect of Borrowing Constraints on Production Choices

Instrumental Variables Estimates
1976-77 to 1983-84

Independent Variable	Index of Crop Diver-sification	Index of Plot Diver-sification	Share of HYV Castor	Share of Trad. Castor	Share of HYV Rice
Borrowing Constraint	1.67*	6.42**	4.82	-4.29*	-27.50**
	(1.46)	(2.91)	(0.63)	(1.58)	(1.69)
Deep Soil	-2.60	-2.07	8.16	68.05	-144.66
	(0.21)	(0.08)	(0.09)	(1.23)	(0.79)
Shallow Soil	-2.55	-1.78	8.73	68.14	-145.65
	(0.20)	(0.08)	(0.09)	(1.23)	(0.80)
Poor Soil	-2.50	-1.50	8.31	67.81	-149.32
	(0.20)	(1.06)	(0.09)	(1.22)	(0.82)
Adult Equiv. Family Size	0.00	0.03**	0.04	-0.05	-0.40**
	(0.40)	(1.97)	(0.58)	(1.48)	(2.40)
Age of Household	0.00	-0.00	0.01	0.00	0.10**
Head$_t$ (0.86)	(0.34)	(0.98)	(0.16)	(2.25)	
Education	0.01	0.04**	-0.01	-0.05**	-0.08
	(1.40)	(4.89)	(0.19)	(2.78)	(1.35)
Constant	2.76	2.14	-8.03	-66.01	145.76
	(0.21)	(0.09)	(0.09)	(1.19)	(0.80)
Number of Observations	236	236	63	147	80

NOTES: Equations are estimated with time fixed effects. Absolute values of t-statistics are in parentheses. See Appendix for data definitions. The instruments are initial holdings of jewelry, consumer durables, buildings, stocks, and land. A double asterisk indicates significance at the 5% level in the one-sided t-test. A single asterisk indicates significance at the 10% level.