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Risk and Insurance In Village India

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Risk and the presence or absence of risk reduction mechanisms at the village and regional level condition opportunities for policy reform. A question, somewhat prior to the policy reform question, is thus clearly posed: how good or how bad are the existing institutions. In villages in southern India important risks are erratic rainfall, crop and human diseases, and severe income fluctuations. Previous research, by studying only one market or institution, may have neglected smoothing possibilities between markets or institutions. A general equilibrium framework is developed to overcome this problem, assessing risk-sharing markets or institutions in a more unified context. Using household data from three villages in southern India, a significant comovement in consumptions suggest that local financial markets there are good, if not perfect, but several anomalies exist, including the low impact of income on consumption and the effect of time varying characteristics such as land holdings on consumption. An explicit private information model could be consistent with the extent of comovement in consumptions while delivering some of these anomalies.

1. Introduction

People in the villages of southern India, and throughout much of the underdeveloped world, live in poor, high risk environments. Per capita income and per capita consumption numbers are low, and the risk for agriculture from erratic monsoon rains is high. Crops and human diseases are also prevalent.

Various policy issues turn on this level of risk and on the presence or absence of risk reduction mechanisms at the village and regional level. First, are landless laborers and the especially poor particularly vulnerable to adverse shocks? Are these people isolated from the rest of the community by some hierarchical class or caste structure, sufficient so that a special welfare policy is necessary? Second, are informal credit markets sufficiently flexible as regards the repayment of loans in bad years, or does the level of risk cause adverse fluctuations in consumption. Third, does reliance on family members as an insurance network cause high population growth with its long run empoverishing effect on human welfare? In short, is there some scope for policy or policy reform?

A question, somewhat prior to the policy question, is thus clearly posed: how good or how bad are the institutions which might potentially insure people in villages in southern India against erratic rainfall, crop and human diseases, and severe income fluctuations. This question is the subject of this paper.

Among the potential risk-bearing institutions one might evaluate one can quickly think of five. The first is diversification of a given farmer's land holdings into various spatially separated plots and into various crops. The second is storage of grain from one year to the next. The third concerns purchases and sales of assets such as bullocks, if not land. The fourth would be borrowing from village lenders, itinerant merchants, and borrowing-lending more generally. And the fifth would be gifts and transfers in family networks, as mentioned above.

The problem with these questions, and with this list, is that each mechanism or institution on the list is nontrivial to evaluate. Indeed, each entry is a research topic in its own right. Thus, restricting attention primarily to India, and primary to the ICRISAT villages which will be used as a data base for this study, Rosenzweig and Stark (1989), and Rosenzweig (1988), study the role of the family in facilitating transfers among villages in the larger regional context. Similarly Jodha (1978) studies credit markets in the ICRISAT villages, while Bell, Srinivasan and Udry (1988) and Kochnar (1989) do so for villages in the north of India. Walker, Singh and Jodha (1983) study the role of plot and crop diversification in ICRISAT villages, and Rosenzweig and Wolpin (1989) study the role of bullock purchases and sales there. Finally, Cain (1981) studies role of distressed land sales and credit, contrasting ICRISAT villages with villages in Bangladesh.

Again, each of these studies is interesting in its own right. But in studying one market or institution only, the researcher may miss smoothing possibilities provided by another. For example, transfers may be small or missing, but this does not leave the family vulnerable if credit markets function well.

This paper presents a general equilibrium framework which can overcome this problem of looking at risk-sharing markets or institutions one at a time. Specifically, the general equilibrium model inevitably leads the researcher to focus on outcomes, namely, consumptions and labor supplies, so that all actual and potential institutions of any kind are jointly evaluated.

Wilson (1968) and Diamond (1967) derived the basic proposition, that if preferences are time separable and display weak risk aversion, if all individuals discount the future at the same rate, and if all information in held in common, then an optimal allocation of risk bearing of a single good in a stochastic environment would imply all individual consumptions are determined by aggregate consumption, no matter what the date and history of shocks, and all consumptions would comove together. Further, controlling for aggregate consumption, individual crop outputs, income, sickness, unemployment and other idiosyncratic shocks should not influence consumption at all. These implications hold in a multiple commodity world under separable preferences, though separability is not necessary, as shown by Mace (1988), or can be controlled for, as shown here; and survive virtually all specifications of technology, as shown by Scheinkman (1984) and Townsend (1990).

Intuition for the results can be garnered by consideration of a two-agent economy with one risk averse farmer experiencing crop fluctuations and one risk neutral insurer. Without information or enforcement problems, the risk averse agent can be completely insured, so his crop fluctuations do not matter for his consumption. Further, even if both agents are risk averse, any arrangement which has one risk averse agent absorbing all his own fluctuations cannot be optimal, because the other agent would be locally risk neutral at the proposed allocation with respect to fluctuations of the first. In an optimal arrangement both would coinsure the fluctuations of each, though the extent of coinsurance depends on preferences. Similarly, we can allow as many agents as we want. Thus, in an optimal arrangement, consumption allocations are determined <u>as if</u> all crop outputs over all agents were pooled together and then redistributed. The pile of grain for distribution is aggregate consumption, and it is determined by aggregate, uninsurable risk. Controlling for aggregate consumption, individual crops outputs and other idiosyncratic risks should have no impact on consumptions whatever. Finally, controlling for aggregate consumption, one need not assume a closed economy. Fluctuations in aggregate village consumption represents the residual, village risk which the larger regional economy has not removed.

There are a priori grounds for taking the villages as the natural unit to study. Namely, village economies satisfy the explicit or implicit conditions of general equilibrium modeling, that individuals in the entire community can arrange their institutions and allocations in such a way to achieve a Pareto optimum. Many families have been present for generations; many contemporary residents live, eat, and work in the village; the villages have their own legal systems replete with contract enforcement mechanisms, and village residents may have relatively good information about ability, effort, and outputs of one another. Moreover, residents of poor, high risk villages have a collective incentive to come up with good arrangements: the absence of these can be consumption threatening.

Fortunately, an extraordinary amount of data, including the required consumption data, is available from six, poor, high risk villages in southern India, sampled by the International Crops Research Institute for The Semi-Arid Tropics (ICRISAT). The villages are located in three separate agro-climatic zones (two villages in each) in Mahbubnagar district of Andhra Pradesh and in Sholapur and Akola districts of Maharastra. Consumptions are measured annually from 1975-1984 for up to 40 households in each of three villages, in Aurepalle, Shirapur, and Kanzara.

There has been an increasing amount of empirical work based on the Arrow-Debreu model, as described above, namely Mace (1988), Cochrane (1989), Altonji, Hayashi and Kotlikoff (1989), Abel and Kotlikoff (1988), Carroll and Summers (1989), Deaton (1990) and Rashid (1990). A summary of this literature is reserved for the concluding section of this paper, section 7, which naturally afford an opportunity to compare and contrast the literature to the results of the present study. Suffice it to note here that no one has carried out tests of complete markets or full insurance with data from villages in poor, high risk agrarian environments. Yet, as noted, these villages offer a natural environment in which to test the Arrow-Debreu model, and the policy implications which tie this work to the development literature make the results for villages important in their own right.

A summary of what is actually found in the data is reserved for section 6, though the eager reader may jump there now and then return to the more detailed analytic sections which follow. In particular, section 2 of the paper describes the relevant aspects of production, income, and risk in these ICRISAT villages by setting down the production technologies of a neoclassical model. Among other things this section offers fairly decisive evidence that even within villages not all households are planting the same crops in the same soils and experiencing the same weather. Section 3 describes some aspects of household demographics, setting down the commodity space and individual preferences. Section 4 then presents the programming problem for the determination of Pareto optimal allocations and delivers exact risk sharing rules for two particular preference specifications, allowing for movement in household demographics. Section 5 describes the analog decentralized, complete markets solution, describing the relationship between Pareto weights in the programming problem and wealths in the decentralized solution. Again, section 6 then presents the empirical results, and section 7 the comparisons to the literature and the conclusions.

2. Production, Income, and Risk

As already noted, the villages in the semi-arid tropics of south India sampled by ICRISAT are primarily agrarian economies subject to high risk. The dominant crops of Aurepalle are castor, a cash crop; a sorghum/pearl millet/pigeon pea intercrop mixture; and paddy. With the exception of paddy, these crops are dry land crops and are grown in the Kariff (monsoon) season. Table 1 gives the coefficients of variation (on the diagonal) and cross crop correlations (off the diagonal) of profits per acre for each of these crops, using the ICRISAT plot data for any sampled household who produced a specified crop in any given year from 1975-1984. The associated standard errors (on the diagonal) and approximate 95% confidence interval (off the diagonal) are given in parenthesis.[1] The salient characteristic of Aurepalle's agriculture is that coefficients of variation are relatively high, ranging from .51 to 1.01, and cross crop correlations are relatively low, ranging from .09 to .81. Thus diversification across crops might seem to be a sensible strategy to reduce risk, at least in autarky, and the farmers themselves agree in conversations that there is an advantage in doing so. We shall come back to this subject momentarily. Similarly, the soil is not uniform in Aurepalle. Taking castor as an example, Table 2 gives the associated coefficients of variation and cross soil correlations for castor planted in medium to shallow black soil and in shallow red soil. The same diversification comment applies. Farmers are keenly aware of soil differences and have their own local vocabulary for soil types; see Dvorak (1988).

Similar comments apply for the village of Shirapur with the exception that Shirapur's soils are retentive of moisture so that post monsoon (Rabi) planting is an important activity. Table 3 thus distinguishes the various dominate crops of rabi sorghum and also (aggregated) pulses distinguished by kariff and rabi planting. As in Aurepalle, one faces considerable risk, yet there remain diversification possibilities. Similarly, taking one rabi sorghum type as an example, cross soil correlations of sorghum yields are relatively low, in Table 4.

Relative to Aurepalle and Shirapur, Kanzara presents a picture of apparent uniformity, with most households planting some cotton intercrop mixture in medium black soils in the Kariff season. Rainfall in Kanzara is also more abundant and less erratic in amount and timing.

Are most households doing the same thing and experiencing the same outcomes in any one of these three villages? Apparently not, despite the diversification possibilities noted above. Most households do not hold a "market portfolio" of crops or soil types, at least not in Aurepalle and Shirapur. Looking at crops planted by each of the surveyed households in 1976, one at a time, for example, it seems proportions among the dominate crops vary considerably, and indeed the residual category of minor crops often constitutes a substantial category for any given household. See Tables 5 and 6.

Individual crop profits are no doubt measured with error, as are incomes generally. In the analysis below this will loom as a potentially significant feature. Indeed, household consumptions will be shown to move substantially with average consumption and to move little with individual incomes. This might suggest that actual incomes have a large common component which is better measured by average consumption than by the individual incomes themselves. Still, the analysis above suggests this is not the case, at least not for Aurepalle and Shirapur. Specifically, the variance, co variance numbers are obtained by averaging over households with the same crop-plot technologies, thereby removing much measurement error at the individual level. These reasonably well-measured variance, co variance numbers show the various crop plot technologies to be distinct. Tables 5 and 6 show, without much measurement error at all, that farmers are not holding the "market portfolio" of these technologies. Thus incomes across farmers appear not to have a large common component.[2]

The picture that emerges, then, is that of a risky village environment with substantial diversity across households in crop-plot "endowments" or technologies. To model this more formally let $N_{\ell}^{k}(\varepsilon_1,\ldots,\varepsilon_t)$ denote the number of acres of land type ℓ held by household k at the beginning of date t when the history of shocks from dates 1 through t has been $(\varepsilon_1,\ldots,\varepsilon_t)$. These land "endowments" are allowed to "move around" over time and shocks for any given household, reflecting actual movement in owned and operated holdings in the data. Land types refer to soil types and irrigation status. Similarly, let $B_{b}^{k}(\varepsilon_1,\ldots,\varepsilon_t)$ denote the number of units of livestock of type b held by household k in these circumstances. At least one type of livestock, bullocks, is used directly in farming. For purposes here we shall assume land and bullocks must always be used in fixed proportions, e.g. each acre of land type ℓ requires α_ℓ units of bullocks and zero units of the other animals. These proportions are always maintained across households, that is, the required number of bullocks is always available for production of land $N^k_\ell(\varepsilon_1,\ldots,\varepsilon_t)$ regardless of shifting land ownership patterns.[3]

At any date t and under any history $(\varepsilon_1,\ldots,\varepsilon_t)$ each unit of land type ℓ and the associated bullock input α_ℓ are used in combination with a vector of agricultural (A) inputs, a^A_ℓ, namely labor, pesticide, fertilizer, and seed, to procure a vector of agricultural outputs q^A_ℓ, namely, the principal crop, or a vector of multiple crops, plus any byproducts such as fodder. Thus each unit of land type ℓ and the associated bullocks is associated with a production technology $f_\ell(\varepsilon_1,\ldots,\varepsilon_t)$ specifying inputs vectors a^A_ℓ and output vectors q^A_ℓ which are feasible with one another. This technology set depends on the contemporary shock ε_t, capturing the extent and variability of rainfall, as well as temperature, humidity, and also the extent of crop disease. In addition past shocks $(\varepsilon_1,\ldots,\varepsilon_{t-1})$ are included to capture the effect of past weather on the water table. For simplicity contemporary shocks ε_t and, of course, past histories $(\varepsilon_1,\ldots,\varepsilon_{t-1})$ are assumed to be known at the very beginning of date t, so that production decisions can be made contingent upon them.[4] Hence the subsequent notations $a^A_\ell(\varepsilon_1,\ldots,\varepsilon_t)$ and $q^A_\ell(\varepsilon_1,\ldots,\varepsilon_t)$ for agricultural input and output vectors, respectively. Note that crop choice and crop rotation can be modeled in this way, allowing zeros in the vector of potential outputs, possibly changing over states and dates.

All inputs and outputs over a land type ℓ can be purchased and sold in a "district" market at exogenously given vectors of prices $P^A_{q\ell}$ for outputs and $P^A_{a\ell}$ for inputs, respectively. From among the inputs we note that labor's price is a wage, W, here assumed to be independent of the land type ℓ (or any other labor use, for that matter). The village is thus imagined to be sufficiently small relative to the "district" market that its input and output decisions do not influences district prices. Prices may also move with states ε_t which are not experienced by any given village. Thus state vector ε_t is hereby expanded to capture this exogenous price variability. Hence the vector notation $P^A_{q\ell}(\varepsilon_1,\ldots,\varepsilon_t)$ and $P^A_{a\ell}(\varepsilon_1,\ldots,\varepsilon_t)$.

The primary virtue of this conceptualization of shocks and markets in the village economy is that efficient, profit maximizing production decisions will be uniform across all households with access to any given land type ℓ, assuming in effect that within period credit markets allow farmers to finance agricultural operations. That is, the simple objective of any farmer faced with a unit of land holding $N^k_\ell(\varepsilon_1,\ldots,\varepsilon_t)$ and associated bullocks $\alpha_\ell N^k_\ell(\varepsilon_1,\ldots,\varepsilon_t)$, however acquired, is to maximize within period net revenues, profits, once shock ε_t is realized. Specifically, the objective of any farmer for whom the amount of land type ℓ is nonzero is to choose output vector $q^A_\ell(\varepsilon_1,\ldots,\varepsilon_t)$ and input vector $a^A_\ell(\varepsilon_1,\ldots,\varepsilon_t)$ to maximize

$$P^A_{q\ell}(\varepsilon_1,\ldots,\varepsilon_t)\cdot\, q^A_\ell(\varepsilon_1,\ldots,\varepsilon_t) - P^A_{a\ell}(\varepsilon_1,\ldots\varepsilon_t)\cdot\, a^A_\ell(\varepsilon_1,\ldots\varepsilon_t)$$

subject to

$$q^A_\ell(\varepsilon_1,\ldots,\varepsilon_t) \text{ and } a^A_\ell(\varepsilon_1,\ldots\varepsilon_t) \text{ elements of set } f_\ell(\varepsilon_1,\ldots,\varepsilon_t).$$

Let $\Pi^A_\ell(\varepsilon_1,\ldots,\varepsilon_t)^*$ denote the maximized profit number per unit land type ℓ.

By the obvious separation theorem, a typical farmer can be thought of as purchasing all inputs in the district market and selling all outputs there, independent of his own labor-leisure, consumption choices, to be modeled below. Indeed, looking ahead for a moment, all spot prices can be taken to be normalized at each date by the price of a single consumption good, $P_c(\varepsilon_1,\ldots,\varepsilon_t)$, so that profits do not reflect inflation. This conceptualization of profit maximizations underlies the actual calculation of the coefficients of variation and correlation statistics presented earlier in the tables. Namely, returns to land-cum-bullocks are taken as the relevant measure profits. Land rentals and bullocks rentals are not subtracted in the calculation of profits given in the tables.[5]

As noted, household k has an "endowment" of various types of livestock, namely, $B_b^k(\varepsilon_1,...,\varepsilon_t)$ of type b at date t conditioned on history $(\varepsilon_1,...,\varepsilon_t)$. Included would be cows capable of producing milk products, sheep capable of producing wool, and so on. Manure is also a natural by product. Animals in turn require inputs such as labor care and fodder. So, as before, let q_b^L denote a vector of outputs per unit livestock (L) of type b and a_b^L an associated vector of per unit livestock inputs, presumed to be feasible under livestock technology set $g_b(\varepsilon_1,...,\varepsilon_t)$. Let $P_{qb}^L(\varepsilon_1,...,\varepsilon_t)$ and $P_{ab}^L(\varepsilon_1,...,\varepsilon_t)$ be the associated district prices for outputs and inputs and let $\Pi_b^L(\varepsilon_1,...,\varepsilon_t)^*$ denote the per unit maximized profit number at these prices. That is, maximize

$$P_{qb}^L(\varepsilon_1,...,\varepsilon_t)\cdot q_b^L(\varepsilon_1,...,\varepsilon_t) - P_{ab}^L(\varepsilon_1,...,\varepsilon_t)\cdot a_b^L(\varepsilon_1,...,\varepsilon_t)$$

subject to $q_b^L(\varepsilon_1,...,\varepsilon_t)$ and $a_b^L(\varepsilon_1,...,\varepsilon_t)$ as elements of $g_b(\varepsilon_1,...,\varepsilon_t)$. The maximized profit, $\pi_b^L(\varepsilon_1,...,\varepsilon_t)^*$, will contribute to what is coded in the data as profits from livestock.

For simplicity the livestock profit maximization condition does not interact with the crop profit maximization condition. Finally, note the "endowment" $B_b^k(\varepsilon_1,...,\varepsilon_t)$ may move around with births and deaths of animals. States of the world ε_t are hereby expanded. For that matter, age of animals could be incorporated into the analysis, though this only makes the notation more complicated.

In Aurepalle palm trees represent a third kind of asset, in addition to livestock and land. But the analysis can be handled in a similar fashion, yielding profits from the sale of palm liquor, namely toddy. These are coded in the data as profits of trade and handicrafts.

Finally pumps and wells can be acquired over time, potentially turning dry land into wet land. This investment is ignored here as a decision variable, though the outcome is picked up in the notation of changing land types.

Households can work for themselves and for others in all the above mentioned activities. Thus, the theoretically relevant concept of income is the contribution to full income, the wage multiplied by the time endowment. However, one can also look at the more "intuitive" measure of labor income, the amount that is potentially available for consumption after subtracting off leisure, namely, earned wages.

Indeed, the composition of income over these four principle components -- agricultural, livestock, trade and handicrafts, and labor income -- vary by household land class and by village, as depicted in Figures 1, 2, 3, and 4. The mix or proportions do vary by landless and by village. Yet profits from crop production remains the principle component for medium and large farmers, and for the villages as whole, roughly 46% on average. Livestock and especially labor income may be more important for landless and small farmers, but are 17% to 29% on average for villages as a whole.

As with the variance, co variance analysis for crop profits, it can be shown that, with the exception of Kanzara, there are diversification possibilities over these components of income (see Tables 7, 8, and 9). Yet, as is evident in Figures 1-4, not everyone is holding the "market portfolio". Livestock production is typically the least risky enterprise, and surprisingly, earned income the most.

As has already been emphasized, the net effect of this risk coupled with failure to take advantage of relatively low cross soil, cross crop, and cross activity correlations is that households have incomes which do not comove together. This is evident in time series Figures 8, 9 and 10, plotting incomes over all continuously sampled households for the 10 year period. These figures also reveal the diversity in incomes in the cross-section, over households at a point in time. The correlation coefficients of household incomes with aggregate village income are given in Figures 5, 6, 7 for each of the three villages. Even in the apparently uniform village of Kanzara, there seems to be considerable household diversity. (These are age sex adjusted per capita incomes, as described below).

3. Household Demographics, the Commodity Space, and Individual Preferences

In 1975 the population of Aurepalle, Shirapur, and Kanzara was 2856, 2079, and 1014 individuals, respectively, or 476, 297, and 169 households, respectively. Over the 10 years through 1984 households sizes have moved with births and deaths. Also individuals have moved in and out of households with temporary and permanent migration. Likewise, marriages and eventual divisions of extended families caused occasional and considerable movement in the number of individual N_t^i in a given household i at date t. All these demographic events are treated here as exogenous and random, and the state variable ε_t is hereby expanded to allow an enumeration. The effect, formally, is to allow an analysis of risk bearing which includes these demographic factors as risks. Of course many of these events reflect underlying decisions. Here it is the outcomes of these choices, only, which are captured mechanically in the notation.

With all these fluctuations in household size, it seemed that the individual rather than the household would be the more stable unit for purposes of analysis. Thus preferences are modeled at the level of the individual, and households are treated as changing clusters of individuals. At the same time the state variable ε_t is expanded to allow an enumeration of the individuals in the various households.

Thus let $\bar{U}^k(c, \ell)$ denote the basic, within-period utility function for consumption c and leisure ℓ by individual k, assuming the individual is alive and present in the village economy in a given period. Consumption c can in general be taken to be a vector of goods. However, a harsh but simplifying feature of these village economies is the preponderance of food in the budget (and much of this is grain). Indeed, food accounts for 78% of consumption on average. With the addition of clothing one can account for 88% of all household consumption.[6] Durables such as watches, radio, and bicycles are still relatively rare, and the service flows are difficult to measure, as would be the flow from housing. In the end, then, consumption c is taken to be a scalar, the nominal value of food and clothing divided by a cost of living index.[7]

The consumption good is imagined in the model to be purchased in the district market at price $P_c(\varepsilon_1,\dots,\varepsilon_t)$ at date t and state $(\varepsilon_1,\dots,\varepsilon_t)$, but as noted above, this is normalized to unity.

Leisure is treated as a separate consumption good for purposes of modeling the village economy. In particular, each individual k has an endowment $T^k(\varepsilon_1,\dots,\varepsilon_t)$ of units of time (days), and this can move with the date and state. In particular, this time endowment can shrink with illness, a frequent shock in the village economy. As before, state ε_t is expanded to allow an enumeration of illness in the village economy.[8]

Thus each individual is imagined to have a utility function $\bar{U}^k(c, \ell)$ over state contingent consumptions and leisures, namely

$$(1) \quad \bar{U}^k[c^k(\varepsilon_1,\dots,\varepsilon_t),\ \ell^k(\varepsilon_1,\dots,\varepsilon_t)]$$

Consumption $c^k(\varepsilon_1,\dots,\varepsilon_t)$ is restricted to be non negative and leisure is bounded between zero and the time endowment,[9] $0\le\ell^k(\varepsilon_1,\dots,\varepsilon_t)\le T^k(\varepsilon_1,\dots,\varepsilon_t)$.

A presumed key feature of the environment is risk aversion. The functions $\bar{U}^k(\cdot,\cdot)$ are taken to be strictly concave.

Births, deaths, and migrations cause the number of individuals alive and present in the village economy to vary over time. The utility, consumption and leisure variables are all set at zero for dead or unborn individuals. Otherwise, all individuals discount the stream of future within-period utilities at common rate β. Suppose in particular there is an initial date t=0 in the distant past and one future doomsday date T. Let the probability of any history $(\varepsilon_1,\ldots,\varepsilon_t)$ be denoted $\text{prob}(\varepsilon_1,\ldots,\varepsilon_t)$. Then, setting aside for the moment the issue of migration, the objective function for each individual as of date t=0 would be *ex ante* discounted expected utility, or

$$(2) \quad \sum_{t=1}^{T} \beta^t \sum_{(\varepsilon_1,\ldots,\varepsilon_t)} \text{prob}(\varepsilon_1,\ldots,\varepsilon_t)\ \bar{U}^k[c^k(\varepsilon_1,\ldots,\varepsilon_t),\ell^k(\varepsilon_1,\ldots,\varepsilon_t)]$$

By also setting the utility term of migrants at zero, and treating migration states as exogenous as indicated above, one gives up on any attempt to integrate migration decisions with the analysis of risk bearing. Thus all statements below on Pareto optimal allocations should be understood to be conditional on migration states.[10]

Individuals alive and present in the village economy differ by age and sex, and this must be taken into account in the determination of consumption needs. In particular a dietary survey of Ryan, Bidinger, Pushpamma, and Rao (1985) was used to construct age-sex consumption weights, using caloric intake for distinct, age-sex categories, averaging over season, land class and village. The weights used here appear in Table 10.

There are two alternative ways to incorporate these and other demographic effects. One is to be explicit about functional forms and to be explicit about the demographics. This lets theory guide the regression equations, entirely. The second strategy is to include an arbitrary vector of demographic control variables in the regressions derived from a theory which is not explicit about demographics.

We adopt the former strategy but report as well on a version of the second strategy. In particular household size is included as an additional variable capturing economies of scale in household production.

To be explicit about functional forms let A_t^k denote the age-sex index for individual k at date t. Utility functions are now presumed to be separable between consumption and leisure and in consumptions to take on either a common exponential or power form. Namely let

$$\bar{U}^k[c_t^k, \ell_t^k] = U^k[c_t^k] + V^k(\ell_t^k)$$

where

$$(3) \quad U^k(c_t^k, A_t^k) = -\frac{1}{\sigma} \exp(-\sigma c_t^k / A_t^k)$$

$$(4) \quad U^k(c_t^k, A_t^k) = \frac{1}{\gamma} (c_t^k / A_t^k)^{\gamma}.$$

If all individuals within a household are treated equally, then these utility functions are consistent with equalizing consumption per unit age/sex index across individuals in a household. This is consistent with the use of the data summarized in Table 10.

Adjusted consumption need not be equalized across different households, however. The analysis below allows for considerable cross household diversity.

4. The Programming Problem for Delivering Pareto Optimal Allocations

The programming problem for the determination of Pareto optimal allocations can now be easily written. Namely, let λ^k denote the programming weight associated with individual k, and for simplicity suppose

$$0<\lambda^k<1, \sum_{K=1}^{M} \lambda^k = 1$$

where M is the number of individuals ever potentially alive and present in the village economy. The program is simply one of maximizing the sum of weighted utilities subject to resources constraints, namely <u>Program</u> <u>P.O.</u>:

Maximize by choice of consumptions $c^k(\varepsilon_1,\ldots,\varepsilon_t)$ and leisures $\ell^k(\varepsilon_1,\ldots,\varepsilon_t)$ the objective function

$$(5)\quad \Sigma_{k=1}^{M} \lambda^k \Big\{\Sigma_{t=1}^{T} \beta^t \Sigma_{(\varepsilon_1,\ldots,\varepsilon_t)} \text{prob}\,(\varepsilon_1,\ldots,\varepsilon_t)\, \bar{U}^k[c^k(\varepsilon_1,\ldots,\varepsilon_t), \ell^k(\varepsilon_1,\ldots,\varepsilon_t)]\Big\}$$

subject to constraints defining commodity aggregates, for each t, for each $(\varepsilon_1,\ldots,\varepsilon_t)$.

$$(6)\quad \Sigma_{k=1}^{M} c^k(\varepsilon_1,\ldots,\varepsilon_t) \le \bar{c}(\varepsilon_1,\ldots,\varepsilon_t)$$

$$(7)\quad \Sigma_{k=1}^{M} \ell^k(\varepsilon_1,\ldots,\varepsilon_t) \le \bar{\ell}(\varepsilon_1,\ldots,\varepsilon_t),$$

feasibility constraints on consumption and leisure, for each t, for each $(\varepsilon_1,\ldots,\varepsilon_t)$,

$$(8)\quad c^k(\varepsilon_1,\ldots,\varepsilon_t) \ge 0 \qquad 0 \le \ell^k(\varepsilon_1,\ldots,\varepsilon_t) \le T^k(\varepsilon_1,\ldots,\varepsilon_t),$$

and to a village-wide budget constraint,

$$(9)\quad \bar{c}(\varepsilon_1,\ldots,\varepsilon_t) + W(\varepsilon_1,\ldots,\varepsilon_t)\, \bar{\ell}(\varepsilon_1,\ldots,\varepsilon_t) = W(\varepsilon_1,\ldots,\varepsilon_t)\, \bar{T}(\varepsilon_1,\ldots,\varepsilon_t) + \bar{\pi}^A(\varepsilon_1,\ldots,\varepsilon_t)^* + \bar{\pi}^L(\varepsilon_1,\ldots,\varepsilon_t)^*$$

Here $\bar{\pi}^{A*}$ and $\bar{\pi}^{L*}$ denote aggregate profits from agriculture and livestock and $\bar{T}$

the aggregate time endowment. To derive these, consider individual k. Profits from crop production are determined as profits per unit land type ℓ multiplied by the number of units of such land operated, namely,

$$(10)\quad \pi^{Ak}(\varepsilon_1,\ldots,\varepsilon_t)^* = \sum_{\ell} N_{\ell}^{k}(\varepsilon_1,\ldots,\varepsilon_t)\ \pi_{\ell}^{A}(\varepsilon_1,\ldots,\varepsilon_t)^*$$

and similarly for livestock,

$$(11)\quad \pi^{Lk}(\varepsilon_1,\ldots,\varepsilon_t)^* = \sum_{b} B_{b}^{k}(\varepsilon_1,\ldots,\varepsilon_t)\ \pi_{b}^{L}(\varepsilon_1,\ldots,\varepsilon_t)^*.$$

Aggregate profits are then just the sum over individuals, or

$$(12)\quad \sum_{k=1}^{M} \pi^{Ak}(\varepsilon_1,\ldots,\varepsilon_t)^* = \bar{\pi}^{A}(\varepsilon_1,\ldots,\varepsilon_t)^*$$

$$(13)\quad \sum_{k=1}^{M} \pi^{Lk}(\varepsilon_1,\ldots,\varepsilon_t)^* = \bar{\pi}^{L}(\varepsilon_1,\ldots,\varepsilon_t)^*$$

and similarly for the time endowment.

$$(14)\quad \sum_{k=1}^{M} T^{k}(\varepsilon_1,\ldots,\varepsilon_t) = \bar{T}(\varepsilon_1,\ldots,\varepsilon_t)$$

Aggregate budget equation (9) is nothing other than a balance of payments equation for the village as a whole: total expenditures on consumption and leisure cannot exceed full income, or, subtracting off labor from the time endowment, the value of consumption imports cannot exceed earnings from labor supply plus net profits. Finally, there is nothing essential about balancing the village budget in any given year. In particular it is to be understood that appended to the right hand side of (9) is an income transfer, if positive, of the form

$$(15)\quad B(\varepsilon_1,\ldots,\varepsilon_t) - [1 + r(\varepsilon_1,\ldots,\varepsilon_{t-1})]\ B(\varepsilon_1,\ldots,\varepsilon_{t-1}) + G(\varepsilon_1,\ldots,\varepsilon_t)$$

to reflect net borrowing in the district at exogenous, date t and $(\varepsilon_1,\ldots,\varepsilon_t)$ state-contingent interest rates r_t and to reflect net gifts or incoming remittances in amount $G(\varepsilon_1,\ldots,\varepsilon_t)$. Indeed, one can adopt the more general notation $\bar{\tau}\ (\varepsilon_1,\ldots,\varepsilon_t)$ of state-contingent village-wide transfers of the consumption good as if these were determined prior to the risk-sharing problem at hand, in either complete or incomplete markets at the district level.

As noted, the objective function (5) in Program P.O. is just the weighted sum of utilities for all potentially alive and present individuals in the village economy. At the level of a given household one could take the head at date t=0 as altruistic, caring about the utility of all present and potential future members, with their utility terms entering additively onto his. This delivers the intergeneration strings in the objective function (5) as in the work of Barro (1981) and Altonji, Hayashi, and Kotlikoff (1989). However, the sum in (5) is over all households, as if they cared about one another as well. These interpretations are not necessary, however, neither under the present programming problem nor complete markets interpretation below.

If utility functions are separable in consumption and leisure and nonnegativity constraints on consumption are not binding, then the first-order conditions determining consumptions are essentially determined by maximizing objective function (5) subject to (6) alone, yielding

$$(16)\quad \lambda^k U^{k\prime}\,[c^k(\varepsilon_1,\ldots,\varepsilon_t)] = \lambda^{\tilde{k}} U^{\tilde{k}\prime}\,[c^{\tilde{k}}(\varepsilon_1,\ldots,\varepsilon_t)] = \mu_c(\varepsilon_1,\ldots,\varepsilon_t)$$

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for all individuals such as k, $\tilde{k}$ alive and present at date t and state $(\varepsilon_1,\ldots,\varepsilon_t)$, say number $M(\varepsilon_1,\ldots,\varepsilon_t)$. Here $\mu_c(\varepsilon_1,\ldots,\varepsilon_t)$ is the common Lagrange multiplier on constraint (6). The common term β^t prob$(\varepsilon_1,\ldots,\varepsilon_t)$ on the left hand side of (16), across individuals k and $\tilde{k}$, has been factored out. By a derivation similar to the one given in Mace (1988), but respecting varying family size numbers $N_t^i(\varepsilon_1,\ldots,\varepsilon_t)$ over N households, as well as age-sex categories, one obtains the formulas:

$$(17)\quad \sum_{k=1}^{N_t^i} c_t^k \Big/ \sum_{k=1}^{N_t^i} A_t^k = (1/N) \sum_{j=1}^{N} \left[\sum_{k=1}^{N_t^j} c_t^k \Big/ \sum_{k=1}^{N_t^j} A_t^k \right] + \frac{1}{\sigma}\left[\ln\lambda^i - \sum_{j=1}^{N} \ln\lambda^j/N\right] +$$

$$\frac{1}{\sigma}\left[\frac{\ln \sum_{k=1}^{N_t^i} (1/A_t^k)}{N_t^i} - \frac{1}{N}\sum_{j=1}^{N} \frac{\ln \sum_{k=1}^{N_t^j} (1/A_t^k)}{N_t^j} \right]$$

$$(18)\quad \ln\left(\sum_{k=1}^{N_t^i} c_t^k \Big/ \sum_{k=1}^{N_t^i} A_t^k\right) = (1/N) \sum_{j=1}^{N} \left[\ln\left(\sum_{k=1}^{N_t^j} c_t^k \Big/ \sum_{k=1}^{N_t^j} A_t^k\right) + \frac{1}{1-\gamma}\left[\ln\lambda^i - \sum_{j=1}^{N} \ln\lambda^j/N\right]\right.$$

$$-\frac{1}{1-\gamma}\left[\frac{\sum_{k=1}^{N_t^i} \ln A_t^k}{N_t^i} - \frac{1}{N}\sum_{j=1}^{N} \frac{\sum_{k=1}^{N_t^j} \ln A_t^k}{N_t^j} \right]$$

for utility functions (3) and (4), respectively. In (17) and (18) per person age-sex adjusted consumption in family i is determined by the analog economy-wide average of this variable, one to one. However, fixed effects are allowed in the intercepts, specifically, the weight of household i relative to the village average. There is a second-order demographic adjustment term as well.[11] Note that apart from intercepts everything in these equations is measured in the data, noting in particular that consumption is measured at the household rather than the individual level. These then are the equations which will be taken to the data.

Equations (17) and (18) may be viewed as polar if not extreme cases of the more general implications predicted by the full risk sharing model. In (17) all variation across households is in the intercepts. In (18), undoing the logs, all variation is in the slope coefficients on aggregate consumption. In the pooled, cross sectional regressions each of these restrictions can be imposed, one at a time. But in running the time series regressions for households one at a time, both intercepts and slope terms are allowed to vary; in effect, a "mongrel" of the two polar forms not derived from utility maximization is taken to the data. Ideally one would like to do nonparametric analysis of the more general implication that individual consumptions should move monotonically with aggregate consumption and with nothing else. But ten data points per household precludes this kind of data analysis here.

If utility functions are nonseparable in consumption and leisure, then first-order conditions (16) would need to be expanded to allow the equating of marginal utilities of leisure. In particular consumption and leisure allocations would interact. Still, aggregate leisure and aggregate consumption would be sufficient to determine all individual allocations if no nonnegativity or upper bound constraint on leisure or consumption were binding. This suggests regression equations somewhat akin to (17) and (18) with the inclusion of aggregate leisure to control for the nonseparability. Measures of leisure and labor supplied are also available from the ICRISAT data.

5. The Decentralized, Complete Markets Interpretation

Under the presumed, regular, neoclassical environment of these village economies, a decentralized complete markets competitive equilibrium would be one of the many Pareto optima traced out as solutions to program P.O. as the λ^k- weights are varied. In particular, in a complete markets equilibrium (i) each individual would maximize *ex ante* expected utility in an initial date t=0 market subject to one budget constraint and (ii) all markets would clear. The commodities traded at date t=0 would be date and state contingent consumptions, with expenditures bounded by initial wealth. That is, a complete markets equilibrium (CME) would have the following, first definition.

Definition CME I:

A specification of the $c^k(\varepsilon_1,\ldots,\varepsilon_t)^*$ and the $\ell^k(\varepsilon_1,\ldots,\varepsilon_t)^*$ over all individuals k and prices $p_c(\varepsilon_1,\ldots,\varepsilon_t)^*$ and $w(\varepsilon_1,\ldots,\varepsilon_t)^*$ for these such that

(i) individual maximization:

for each individual k the $c^k(\varepsilon_1,\ldots,\varepsilon_t)^*$ and the $\ell^k(\varepsilon_1,\ldots,\varepsilon_t)^*$ maximize objective function

$$(19)\quad \sum_{t=1}^{T} \beta^t \sum_{\varepsilon_1,\ldots,\varepsilon_t} \text{prob}(\varepsilon_1,\ldots,\varepsilon_t) \bar{U}^k \left[c^k(\varepsilon_1,\ldots,\varepsilon_t),\ \ell^k(\varepsilon_1,\ldots,\varepsilon_t)\right]$$

subject to an initial date t=0 budget constraint

$$(20)\quad \sum_t \sum_{\varepsilon_1,\ldots,\varepsilon_t} p_c(\varepsilon_1,\ldots,\varepsilon_t)^* c^k(\varepsilon_1,\ldots,\varepsilon_t) + \sum_t \sum_{\varepsilon_1,\ldots,\varepsilon_t} w(\varepsilon_1,\ldots,\varepsilon_t)^* \ell^k(\varepsilon_1,\ldots,\varepsilon_t) \le$$

$$\sum_t \sum_{\varepsilon_1,\ldots,\varepsilon_t} p_c(\varepsilon_1,\ldots,\varepsilon_t)^* \left[\pi^{Ak}(\varepsilon_1,\ldots,\varepsilon_t)^* + \pi^{Lk}(\varepsilon_1,\ldots,\varepsilon_t)^*\right] +$$

$$\sum_t \sum_{\varepsilon_1,\ldots,\varepsilon_t} w(\varepsilon_1,\ldots,\varepsilon_t)^*\ T^k(\varepsilon_1,\ldots,\varepsilon_t)$$

(ii) market clearing:

village budget balance equation (9)

The right-hand side of (20) is the wealth of household k at date zero, essentially the discounted present value of profits from agriculture and livestock, plus the value of the time endowment. These wealth terms over households essentially pin down the particular Pareto optimal allocation which the complete markets equilibrium theory predicts should prevail in the data. This relation is particularly strong for the specific utility functions described above, namely for the exponential and power utility functions, for then the Pareto weight λ^k is one to one with either the level or the log value of wealth of household k. This suggests the finding of variables in the data set which might be related to the wealth of household k, checking to see if the levels or logs of these variables are related to the estimated λ^k weight of households k in the regression equations. In particular, if land holdings and livestock are stable over time, then the profit components of wealth would be captured by value of date t=0 land and livestock holdings. A related measure would be the date t=0 value of inheritance.

It will be useful here to imagine that only state contingent claims on consumption are traded at date t=0, determining net transfers of consumption to individual k at date t and state $(\varepsilon_1,\ldots,\varepsilon_t)$ in amount $\tau_c^k(\varepsilon_1,\ldots,\varepsilon_t)$. This simplification draws on the fact that not all contingent claims, especially those on leisure, need be traded if there is subsequent trading in spot markets. Arrow-Debreu securities payable in the numeraire, consumption good are enough. This is also consistent with observed spot market exchange of consumption and leisure, with active labor markets. Still, it will also be useful to image that individuals try to do some of their insurance in the date t=0 market by buying and selling state contingent land titles $\hat{N}_\ell^k(\varepsilon_1,\ldots,\varepsilon_t)$ and livestock titles $\hat{B}_b^k(\varepsilon_1,\ldots,\varepsilon_t)$ at prices

$r_\ell(\varepsilon_1,\ldots,\varepsilon_t)^*$ and $r_b(\varepsilon_1,\ldots,\varepsilon_t)^*$, respectively. This allows these claims to move around though without generating additional spot market revenue. This gives us the second definition of complete market equilibrium.

Definition CME II:

A specification of consumptions $c^k(\varepsilon_1,\ldots,\varepsilon_t)^*$ and leisures $\ell^k(\varepsilon_1,\ldots,\varepsilon_t)^*$ as well as transfers $\tau_c(\varepsilon_1,\ldots,\varepsilon_t)^*$, land titles $\hat{N}^k_\ell(\varepsilon_1,\ldots,\varepsilon_t)^*$ and livestock titles $\hat{B}^k_b(\varepsilon_1,\ldots,\varepsilon_t)^*$ with prices $P_c(\varepsilon_1,\ldots,\varepsilon_t)^*$, $r_\ell(\varepsilon_1,\ldots,\varepsilon_t)^*$, and $r_b(\varepsilon_1,\ldots,\varepsilon_t)^*$ of consumptions, transfers, and these titles, respectively, such that

(i) individual maximization:

for each individual the consumption, leisure, transfers, and title decisions maximize objective function.

$$(21)\quad \sum_{t=1}^{T} \beta^t \sum_{\varepsilon_1,\ldots,\varepsilon_t} \text{prob}(\varepsilon_1,\ldots,\varepsilon_t)\, \bar{U}^k \left[c^k(\varepsilon_1,\ldots,\varepsilon_t),\ \ell^k(\varepsilon_1,\ldots,\varepsilon_t)\right]$$

subject to an initial date t=0 budget constraint

$$\begin{aligned}(22)\quad & \sum_t \sum_{\varepsilon_1,\ldots,\varepsilon_t} P_c(\varepsilon_1,\ldots,\varepsilon_t)^* \tau^k_c(\varepsilon_1,\ldots,\varepsilon_t) + \\ & \sum_\ell \sum_t \sum_{\varepsilon_1,\ldots,\varepsilon_t} \left[\hat{N}^k_\ell(\varepsilon_1,\ldots,\varepsilon_t) - N^k_\ell(\varepsilon_1,\ldots,\varepsilon_t)\right] r_\ell(\varepsilon_1,\ldots,\varepsilon_t)^* + \\ & \sum_b \sum_t \sum_{\varepsilon_1,\ldots,\varepsilon_t} \left[\hat{B}^k_b(\varepsilon_1,\ldots,\varepsilon_t) - B^k_b(\varepsilon_1,\ldots,\varepsilon_t)\right] r_b(\varepsilon_1,\ldots,\varepsilon_t)^* \le 0\end{aligned}$$

where spot market allocations are determined by the spot market budget constraint

$$\begin{aligned}(23)\quad c^k(\varepsilon_1,\ldots,\varepsilon_t) &= W(\varepsilon_1,\ldots,\varepsilon_t)\left[T^k(\varepsilon_1,\ldots,\varepsilon_t) - \ell^k(\varepsilon_1,\ldots,\varepsilon_t)\right] \\ &+ \hat{\pi}^{Ak}(\varepsilon_1,\ldots,\varepsilon_t)^* + \hat{\pi}^{Lk}(\varepsilon_1,\ldots,\varepsilon_t)^* + \tau^k_c(\varepsilon_1,\ldots,\varepsilon_t)\end{aligned}$$

where profits for individual k are now determined by newly acquired titles, namely

(24) $$\hat{\pi}^{Ak}(\varepsilon_1,\ldots,\varepsilon_t)^* = \sum_{\ell} \hat{N}^k_{\ell}(\varepsilon_1,\ldots,\varepsilon_t)\pi^A_{\ell}(\varepsilon_1,\ldots,\varepsilon_t)^*$$

(25) $$\hat{\pi}^{Lk}(\varepsilon_1,\ldots,\varepsilon_t)^* = \sum_{b}\hat{B}^k_b(\varepsilon_1,\ldots,\varepsilon_t)\pi^L_b(\varepsilon_1,\ldots,\varepsilon_t)^*$$

(ii) market clearing in the date t=0 claims market:

(26) for each t, each $(\varepsilon_1,\ldots,\varepsilon_t)$

$$\sum_{k=1}^{M} \tau^k_c(\varepsilon_1,\ldots,\varepsilon_t) = 0$$

(27) for each t, each $(\varepsilon_1,\ldots,\varepsilon_t)$, each land type ℓ,

$$\sum_{k=1}^{M} \left[\hat{N}^k_{\ell}(\varepsilon_1,\ldots,\varepsilon_t) - N^k_{\ell}(\varepsilon_1,\ldots,\varepsilon_t)\right]=0$$

(28) for each t, each $(\varepsilon_1,\ldots,\varepsilon_t)$, each livestock type b,

$$\sum_{k=1}^{M}\left[\hat{B}^k_b(\varepsilon_1,\ldots,\varepsilon_t) - B^k_b(\varepsilon_1,\ldots,\varepsilon_t)\right] = 0$$

The advantage of this formulation is that it makes clear that consumption $c^k(\varepsilon_1,\ldots,\varepsilon_t)$ at each date t might be influenced by profits and other measures of spot market income at each date t as in (23). That is, many alternatives to the complete markets theory give these income variables some influence. The complete markets theory, on the other hand, makes a dramatic prediction: controlling for aggregate consumption there should be no influence of household incomes on household consumptions, whatever. That is, the complete markets theory predicts that transfers τ_c^k will kick in to even out all fluctuations in household income, holding aggregate consumption constant. We shall see below whether the data want to reject the complete markets formulation in favor of the large ill specified class of alterative models.

6. Empirical Results

A salient feature of these village economies is the relatively high co movement of per person age-sex adjusted consumptions across households. This is evident from analogs to the income graphs mentioned earlier in Figures 8, 9, 10, now plotting consumptions against one another and over time, in Figures 11, 12, and 13. Apparent is a tendency toward a "wave-like" movements in which consumptions move up and down together. More formal statistics reveal the same tendency. The correlation of per person age-sex adjusted consumptions, household by household, with the village sample average is displayed in Figures 14, 15, and 16. With a few exceptions, noticeable in Aurepalle, point estimates of the correlations exceed .5 and quickly rise toward unity. Again, the contrast with income, Figures 5, 6, and 7, is obvious.

To carry out more formal tests of the risk-sharing model, one needs to identify the source of error terms in the regression equation. The view taken here is that the dependent variables in equations 17 and 18 are measured with errors which are independent over time for a given household and independent across households at a point in time. This delivers an i.i.d. error term in the time series and cross sectional regressions reported below.[12] On the right hand side of the regressions, the village-wide average consumption variable is approximated by the sample average. One hopes by the law of large numbers that the approximation is fairly accurate. To aid in this, consumptions of so called "discontinuous households", those not sampled over the entire ten year period, were included in construction of the average at each date. Still, the sample average may remain an approximation, and a noisy one at that. Thus, in the time series regressions, examining one household at a time over the ten year period, the average consumption variable does not include the consumption of the specific household under scrutiny. This avoids spurious correlation of the left and high hand side variables and avoids biasing the coefficient on average consumption toward unity. In the cross section regressions, in which households are pooled together, there remains the problem that at any date the average of the dependent variable over households is close to right hand side independent variable; this biases the coefficient toward unity as the right hand side variable approximates an intercept.[13] To avoid this problem in the cross sectional regressions the average consumption variable is subtracted off from the left hand side with a coefficient of unity, as the theory dictates. This still allows one to test for the significance of other variables.[14, 15]

There remains the possibility the sample average consumption, even if close to the true average of the sample, may not approximate well the true average consumption of the entire village economy; the sample of households may not be sufficiently large. But if the world were as the theory postulates this would cause the measured aggregate consumption variable to have less explanatory power, not more. Thus high correlations among consumptions and a good fit in the regression equations cannot be explained in this way.

Tables 11 and 12 report on the benchmark time series regressions 17 and 18, in levels and logs, respectively.[16] The tables give the absolute and relative frequency of right hand side variables as compared with the values predicted by theory, at the 95% confidence level. For example, for the regressions in levels in Aurepalle there is one household with an intercept which is statistically positive, in Shirapur three which are statistically negative and three which are statistically positive, and so on. The number of significant intercepts is low, but the theory only predicts that these should average to zero. (The preponderance of negative intercepts in logs is troublesome). On the other hand, there are only three households in Aurepalle with a coefficient on the average village consumption variable which is statistically different from the predicted value of unity (and one of these is statistically greater than unity). Such "co movement" statistics are strikingly similar in the other two villages. The demographic variable, denoted agedif, is rarely statistically different from zero.

One might be curious about the explanatory power of these household regressions. To that end Figures 17 and 18 report on the R^2's in levels and logs, respectively. Aurepalle and Kanzara have more than a few households at relatively "low" but not negligible values but a substantial number above .5 as well. Shirapur is remarkable in that the bulk of households are above .5, and many higher. In conclusion the explanatory power of these regressions is substantial, though it is difficult to know what to make of a good fit in the absence of prior knowledge of measurement error.

Tables 13 and 14 report on the addition of variables one at a time into these benchmark time series regressions. Again, the theory predicts that no additional variable should be significant. (For that matter, no set of additional variables should be significant; see the results reported below). In practice, additional economic variables enter, but not often. In levels, income from all sources (as distinct from full income) enters in Aurepalle for four households and three in Kanzara; labor income enters for five households in Aurepalle and three in Shirapur; profits from crop production enters for three households in Aurepalle and Kanzara; and full incomes enter for five households in Kanzara. In logs these variables are slightly less likely to enter significantly, with the exception of labor income for four households in all villages and all income for four households in Shirapur. Wages alone, as a measure of substitution between consumption and leisure, appear not to matter much, except in Shirapur, where the sign is negative for four to five households.

A natural question arises: who is not insured in these villages? If we check for the significance of <u>any</u> income term (whether labor income or crop profits or all income) over each and all households we get more rejections and a hint of patterns by land class. Specifically, the landless and small farmers in Aurepalle, the landless in Shirapur, and medium farmers in Kanzara seem slightly more vulnerable. This is apparent in Tables 15 and 16.

It is difficult to display coefficient values for each household. One can report on mean coefficient values as well as the standard deviation of coefficient values in the sampled population. As Deaton (1990) notes, however, not only should the intercepts sum to zero, the average of values on the aggregate consumption variables should approximate unity as well, at least as the sample population goes to infinity. In the finite ICRISAT sample, estimated coefficient values suffer from enormous dispersion in the population, leaving the means at strange if not extreme values. Nor are the average coefficient values on the alternative income variables particularly revealing. A better and more powerful guide to coefficient values for alternative variables comes from pooling the regressions over households.

Thus Tables 17 and 18 report on the benchmark regressions in levels and logs, respectively, both for the benchmark regression, in the top two rows of the tables, and for additional variables entered one at a time in the remaining rows. Unlike the time series regressions in which there is a separate variable such as profits for each household, in the pooled cross section regressions there is only one variables, e.g. profits, entering with the same coefficient values for everyone. The theory predicts a coefficient value of zero.

In Tables 17 and 18 standard errors on coefficient values are reported in parentheses, and the markers * and + indicate significant differences from zero at the 95 and 90 percent confidence levels respectively. An exception to this format is caused by the many intercept terms, one for each household. For these, the number statistically positive and negative are reported, as in the earlier time series tables. Recall also that average consumption is subtracted off the dependent variable in these cross sectional regressions, so comovement of individual with aggregate consumption is not revealed in the tables here.

For the benchmark regressions the second-order demographic terms are occasionally significant, but signs are incorrect. One picks up more intercepts than in the household time-series regressions, no doubt because of the imposed identical unitary coefficient on aggregate consumption. Peculiar, however, is the preponderance of positive coefficients.

Moving to the inclusion of additional variables, crop outputs enter significantly in Aurepalle in levels and logs. However, the coefficient values are low, .05 in levels, .03 in logs. Profits from crop production are insignificant. Labor income is significant in Shirapur in levels and logs, with somewhat higher values, .13 to .10, respectively. Income from all sources is also significant in Kanzara in levels and in Shirapur in logs, at values of .02 and .16 respectively. Full income is insignificant.

Income from labor supply and other income variable may be neither statistically independent from per person consumption not exogenous to the decision problem facing a typical household. Thus the occasional significance of income variables in the regression equations may not strike one as evidence against full insurance. If consumption and leisure are substitutes, for example, an increase in labor supply (leading to an increase in earned income) would lead under substitution to an increase in consumption, other things equal.

As noted earlier, however, one can control for potential nonseparabilities of this sort between consumption and leisure by controlling for aggregate leisure, assuming no boundary constraints on consumption and leisure are binding.

Specifically, as a first approximation, one need only include aggregate leisure in the benchmark regressions. This is also reported in Table 17 and 18 for levels and logs, respectively. The leisure variable fails to be significant.

A word of caution is in order, however. The ICRISAT labor data is noisy. In particular for adult males, for whom the data is most reliable, one observes relatively low measured hours on average, and many males move out of the labor measured labor force for extended periods of time, giving sickness, out of station, holiday, migration and unemployment as reasons for not working. Related, household production activities are not measured in the 1978-1985 data, and the labor day numbers for females and children are thus unreliable. The average leisure variable used above is thus the time endowment of a given adult male in the survey, guessed arbitrarily at 312 days per year, less measured days absent for sickness, averaged over all males in the household, and then averaged over households. This is a noisy measure of true average leisure.[17]

A variable called average labor supply can also be constructed, and this would be equivalent with average leisure up to a constant if the time endowment were constant. It also is insignificant. However, the wage is significant in Shirapur in levels and logs, evidence perhaps of nonseparabilities there. Unfortunately, Shirapur has the most noisy labor data.

Finally, measures of sickness, unemployment, and other reasons for not working can be derived in this way and enter into the benchmark regressions, somewhat akin to the exercise of Cochrane (1989). None of these are significant, with one exception, all reasons for not working, which matters in Kanzara in logs.

There is one set of variables which shows up consistently in the cross sectional regressions, namely, measures of household size.[18] This is evident in Table 17 and 18 for the variables counting all household members as well as variables counting the number of children and number of adults. The coefficients are significantly negative, much of the time. Of course the careful and time consuming work of counting household members, and weighting by age and sex, was meant to capture all the relevant demographics. By that standard, none of these household size variables should have entered. We are left with three interpretations. First the age-sex weights could still be wrong.[19] Second, households are not completely insured against changes in family size. Or, third, there are some economies of scale in some unobserved household production process so that larger households need less measured "consumption inputs" per person to sustain ultimate utility levels. Such "economies of scale" have been estimated in disparate data sets from a variety of countries. For example, see Lazear and Michael (1988).[20] The third explanation thus seems the most plausible; it argues for the inclusion of household size as a standard variable in the benchmark regression.

One might object to entering alternative variables one at a time in these time cross sectional regressions (in contrast to the household regressions where there are a few degrees of freedom). To counter this an entire set of income variables (crop profits, labor income, all income) are entered into the benchmark and also entered jointly with the household size and average labor variables, again, to control for economies of scale and potential nonseparability in consumption and leisure. This is reported in Table 19. Statistically one sometimes rejects the hypothesis that incomes do not matter, as foreshadowed above, but the rejection is weak.

By running the cross sectional regressions for the landless and the landed households separately one can check if income terms are more likely to enter for the poor. Also, because sample average village consumption is no longer the average of the dependent variable, average consumption can be included as a right hand side variable. Thus differential risk aversion as between "rich" and poor can be estimated.[21] This is reported in Table 20 for the regressions in levels with the inclusion of the all-income variable. From the regression it seems that the landless are more risk averse across all villages. On the other hand, the landless poor seem much less well insured than farmers in Shirapur. But the landless are better insured than the farmers in Kanzara. These results are somewhat consistent with the earlier count of households with significant income terms in the time series regressions, Tables 15 and 16, with the landless vulnerable in Shirapur and middle level farmers vulnerable in Kanzara.

One wonders if the full insurance model is being confronted with a powerful alternative. Perhaps contemporary income matters less for consumption than past incomes. Table 21 provides some support for this hypothesis, showing that averages of past income variables having higher coefficient values and/or more significance in Aurepalle and Shirapur. Statistically we begin to soundly reject full income insurance for these villages. Note, however, that the coefficients values stay relatively low, under .10.

Measurement errors in incomes could also cause a downward bias in income coefficient values. Similarly, village average consumption may pick up the effect of individual incomes better than noisy individual estimates. Line 1 in Table 21 tries to control for this, with income more significant than before in Kanzara. Consistent with this, Kanzara is the only village with relatively little cross household diversity as documented above.

Related, the aggregate consumption variable can be excluded from the cross-section regressions altogether (along with the demographic term). Coefficient values are reported in Figure 19. Strikingly, point estimates in Table 21 for the three-year-average variable in Aurepalle and for every income variable in Shirapur stay consistently <u>above</u> the coefficient values displayed in Figure 19. Thus the specification with aggregate consumption subtracted in the cross sectional regressions helps to <u>augment</u> estimates of the income effect in these cases. The more conventional wisdom holds for contemporary and lagged income in Aurepalle and all values in Kanzara. But, in any event, the coefficient values in Figure 19 stay remarkably below .08 or so. Including standard errors pushes the upper bound to .10 only. Income effects, however estimated, are not large.

The relationship between the intercept values in the benchmark cross sectional regressions, as estimates of differential wealths or differential Pareto weights, and actual values of various assets variables is of some interest. This relationship is revealed by regressions of estimated intercept values normalized by standard error of the estimates against values for bullock holdings, land holdings, and inheritance, normalized by standard deviations in the ten year sample, where relevant. See Tables 22 and 23 for the regressions in levels and logs respectively. These regressions reveal that in all three villages operated land holdings are related in a positive way to estimated intercepts, and can explain between 10 to 50% of the variation in the intercepts. Owned bullocks are significant in Aurepalle and Kanzara, explaining between 9 to 70% of the variation, particularly in Aurepalle. Inheritance, on the other hand, is significant in Aurepalle and Kanzara, but tends to have less explanatory power. The theory might have predicted the opposite, that inheritance is the best measured proxy available for the wealth term in the right hand side of the Arrow-Debreu t=0 budget constraint (20) and hence should be close to the intercepts. Landholdings and bullocks, on the other hand, change in value even within a generation in these ICRISAT villages, as documented by Cain (1981) and Walker (1988). These assets thus represent acquired characteristics which should not be highly correlated with the estimated weights. These regressions thus provide fairly decisive evidence against full insurance.

One wonders more generally how acquired characteristics impact on consumption, in particular, whether there are significant shifts in the consumption distribution within the 10 year sample. To find out the sample was divided in half, into two separate five year periods, and a test for the significance of changing intercepts was performed. This is reported in Table 24. In logs 15 out of 34, 7 out of 33, and 12 out of 36 households in Aurepalle, Shirapur, and Kanzara, respectively, have statistically changed intercepts. There is a tendency for changed intercepts among landless and small farmers in Aurepalle, and especially medium farmers in Kanzara, consistent with the earlier results on significance of income terms. The landless in Shirapur are more or less stable. In levels there are fewer households with changed intercepts in the three villages, only 3, 8, and 5 for Aurepalle, Shirapur and Kanzara, respectively. All in all, however, the evidence weighs in against the full insurance model.

Age of the household head is another characteristic which changes over time and should have no bearing on consumptions if the theory is correct. In contrast, an inclusion of age and age squared in the regressions on intercepts are significant in Shirapur and Kanzara and yield a positive life cycle effect, with a peak at roughly age 39 in the two villages. These two age variables can explain up to 20% of the variation in the intercepts. There is no significant effect in Aurepalle.

One also wonders about the influence of other demographic variables, specifically, number of siblings, number of daughters-in-laws of the head, and number of migrants, as suggested by the work of Rosenzweig (1988). None of these variables is significant in any village or any specification here.

7. Comparisons and Conclusions

As noted, there has been an increasing amount of empirical work as of late on the Arrow-Debreu model, much of it rejecting the complete markets hypothesis. Mace (1989) has studied individual household consumption expenditures in the U.S. with the Consumer Expenditure Survey. Under common exponential or power utility functions she derived the implication that either growth rates in household consumptions or changes in levels of household consumptions would be determined by the associated average consumption variable. Further, the addition of household income in her linear regressions should have no explanatory power. Again, this is the test for possible idiosyncratic, uninsured components, a key insight pursued by Cochrane (1989) with a cross-section of families from the Panel Study of Income Dynamics.

The Mace and Cochrane results are sensitive to exactly what measure of consumption is used and what additional variables such as income are tried out on the right hand side of their regressions. Roughly, for Mace, the hypothesis of comovement in consumptions in the U.S. does not do as badly as one might have expected for some commodity groups; still, the regressions have dismal explanatory power, and household incomes do matter. Similarly, Cochrane shows that food consumption growth rates differ across families, namely are lower for families which have experienced extended illness or job layoffs with protected job search; incomes also matter.

In the ICRISAT villages of southern India sickness and unemployment matter little in the determination of consumptions; all reasons for not working has a mild effect. Incomes, on the other hand, matter statistically. That is, the complete markets is rejected in the ICRISAT data. But, overall, the effect of incomes on consumptions. is not high.

Neither Mace nor Cochrane use the time series for particular households in their studies. For Mace, the overlapping panel of the CES makes this impossible, and Cochrane restricts attention to divergence in three year growth rates in a pure cross section, though the PSID would allow time disaggregation. Related, neither Mace nor Cochrane set out to estimate fixed effects on consumption levels across households, to see what these might be related to. Cochrane, but not Mace, controls for demographics by finding a subsample with no demographic changes. This is not possible in ICRISAT data. Hence the effort here to control for demographics by incorporating demographic changes into the theory directly, using supplementary information on age, sex, and caloric weights from a dietary survey.

Independently, Able and Kotlikoff (1988) and subsequently Altonji, Hayashi and Kotlikoff (1989) have been exploring the implication of inter generational altruism for consumptions. They end up studying the relationship among consumptions across families either grouped by age of the household head or by relation to one another as within dynastic families. For them, altruism is a way to motivate the models and to select candidate families, but is the full risk-bearing implications for consumptions which are being examined. The conclusions are mixed. Consumption growth rates across age groups are not statistically different in the CES survey. On the other hand, the consumptions of dynastically related families in the PSID data set are influenced by their own incomes, apparently; this would not be the case if each dynasty collectively faced a collective, dynasty budget constraint. However, Altonji, Hayashi, and Kotlikoff are for the most part imposing equality in weights across families, so that the correlations between family consumption levels and family income levels could be the source of the rejection. Indeed, their rejection is weaker in their times series, dynamic factor model, allowing differential growth rates across households, a model which does not impose the equality restriction.

The Altonji-Hayashi-Kotlikoff results suggest an attempt to identify relationships among households in the ICRISAT sample. It is not yet clear whether the household sample is large enough to do this, and in any event the sample was stratified by land class, not household relationships. Still, a preliminary analysis of consumptions by caste groups failed to turn up anything obvious.

The ICRISAT sample does allow an attempt to measure differential access to insurance by land class groups. The results here, though tentative, suggest that landless and small farmers in Aurepalle, landless households in Shirapur, and medium farmers in Kanzara are more vulnerable to idiosyncratic shocks. Thus mixed support is provided for the common conjecture, noted at the outset, that the poor generally are less connected and more vulnerable.

Altonji, Hayashi, and Kotlikoff control for demographic changes in their work. They make only limited use of the data on wealths. But as Hayashi has suggested, a natural test of altruism is to see if estimated fixed effects or Pareto weights are related to actual wealths. If not, but the consumption data move consistent with full insurance, then one might conclude that something other than market forces is helping to determine the allocation of resources. As it turns out, the fixed effects in the ICRISAT villages are not closely related to the most natural wealth variable theory would suggest, namely, inheritance. And though more related to land holdings and owned bullocks, these two variables have moved within the time span of the present generation of the ICRISAT sample. That and the significant difference in estimated intercept values over the two five year subperiods provide evidence against both altruism and complete markets.

Virtually the only study to statistically accept the hypothesis of complete markets is that of Altug and Miller (1990) with, again, the PSID data. Their tests are different from Mace (1988), Cochrane (1989), and Altonji, Hayashi and Kotlikoff (1989) however, fitting intertemporal and cross household Euler conditions directly. Further, Altug and Miller allow for shocks to preferences and various unobserved but time varying factors meant to capture relative price effects. Unfortunately, their point estimates of risk aversion in the population are implausibly low. A nice aspect of their study is the explicit incorporation of household production and nonseparable preferences, allowing nontrivial interaction of consumption with labor supply. With the present exception, their's is the only other study which combines the analysis of risk bearing in consumptions with risk bearing in leisure.

Virtually the first person to take the consumption implications of complete markets to data was Leme (1984) who showed with graphs that aggregate consumptions across countries do not comove together. Carroll and Summers (1989) have recently amplified on this point, focusing on how country consumptions tract country incomes, and a growing literature in international economics is emerging. It might thus be pointed out that the general equilibrium model with its focus on consumptions offers a way to distinguish aggregate risk from idiosyncratic risk whatever the geographic unit under consideration. This distinction may have been unclear in the discussion thus far. If one takes the village as a natural geographic unit to study, for example, then one must distinguish shocks which are insurable at the individual, household level from shocks to the entire village which are not so insurable. Rainfall may be bad for everyone, for example, though, on the other hand, there is mounting evidence that rainfall is not uniform even within the confines of the lands of a two to three square mile village.[22] In any event, aggregate risk at the village level still may be related to but not identical with aggregate (estimated) regional risk. The extended model thus allows villages to ensure one another, though, again, whether or not they do is an empirical question.

Efforts here to pool the villages of the ICRISAT sample and to test the complete markets hypothesis at the regional level failed to turn up anything decisive. Village consumptions do comove somewhat with a three-village average, excluding the village in question, though Shirapur does much better in this regard than either Aurepalle or Kanzara. Indeed, the inclusion of village income variables in ten year times series regressions can cause the aggregate regional consumption variable to fail to be significant. Yet the village income variables themselves often fail to be significant, unless several are included jointly, and the coefficients on these income variables are sometimes negative, i.e., of the "wrong" sign.

Efforts are underway to test for complete markets at the regional level or national level in other data sets. Rashid (1990) does this with a one year cross section in Pakistan, judiciously using sparse data on wealths. She finds greater co movement in consumptions at the village or district level than at the provincial level, suggesting some fragmentation in national financial markets. Surprisingly, the estimated transitory components of income do not influence consumptions at all. In contrast in some very preliminary work of Deaton (1990) in the Cote d'Avoir, marginal propensities to consume out of current income are high even controlling for village dummies capturing the effect of village consumptions and village incomes.

It thus seems that in the end we will need to develop alternative models of the determination of consumption and leisure. One hopes in this regard that the anomalies which emerge from the full insurance benchmark will provide some guidance for the development of these alternative models. For example, the extent of comovement in consumptions in the ICRISAT Indian data suggest that local financial markets there are good, if not perfect. This is consistent with a priori knowledge gained from earlier studies, of Walker et al (1988) and Cain (1981) showing that ICRISAT households absorb most fluctuations in income by credit transactions, and that, in contrast, purchases and sales of assets and grain inventories play only a limited role. Thus Youngjae Lim (1990) shuts down all insurance and smoothing opportunities other than though credit markets and asks whether this particular alternative model explains the consumption data well.

There are also indications that an explicit private information models of the ICRISAT Indian data might be consistent with the extent of comovement in consumptions while delivering some of the anomalies. In particular, Phelan and Townsend (1989) and Phelan (1990) have shown that in an information-constrained efficient allocation consumptions move with incomes but only very slowly, at least when the model is calibrated against the CES U.S. data. This appears on the face of it to be consistent with the positive but low coefficients measuring the impact of income on consumptions in the ICRISAT data and the effect of time varying characteristics such as land holdings on consumptions. It would be consistent as well with evidence that neoclassical optimization conditions in production are violated, as they may well be in the ICRISAT data. The latter is a test of full insurance and complete markets that takes us well beyond the scope of this paper.

1. These are from T.W. Anderson (1984) and assume 10 observations.

2. Youngjae Lim (1990) has carried out a factor analysis of both consumptions and incomes, reinforcing these conclusions.

3. In fact, it seems there is a lively rental market in bullocks, at least in Aurepalle. This is under study in collaboration with ICRISAT and will be reported in detail at a later date.

4. This is a drastic simplification which does not capture contingent decision making within a crop season or across seasons in a given year.

5. However, profit numbers were compared to those used by ICRISAT, namely returns to family owned resources. Under that conceptualization any input, including labor, which is owned and used in farming is not subtracted as a cost. Orders of magnitude turn out to be similar, with these intriguing exceptions. When using returns to owned resources, coefficients of variation are always less and the cross crop correlations are almost always greater. Profit calculations were also compared to those subtracting off the rental from owned and hired bullocks. These latter profit numbers are lower but the thrust of the variance covariance analysis still applies. An alternative more realistic framework would allow rental of land and bullocks as well as purchases and sales within and across periods. Both can be accomodated. In particular the relevant measure of spot market income (see below) would then be profits net of the rentals of land and bullocks plus revenue from the sale of these assets themselves. An earlier preliminary analysis suggested this latter measure of income is, if anything, at least as variable as the original net income variables used above. However, this is a separate project to be reported more fully in a subsequent paper.

6. This includes, of course, food grown and eaten by the households itself, not just market transactions.

7. Experimentation revealed this choice to fit the data best. Tests were carried out for separability of food from clothing, along the lines of the consumption-leisure analysis described below, and nonseparability was rejected. Aggregate clothing failed to explain individual food expenditures once aggregate food was used in the regression. Grain alone and all food alone were categories also used in much of the risk sharing analysis below, but the value weighted combination food and clothing seemed to fit the data better. None of these specifications altered the salient conclusion: individual consumptions move with aggregate consumptions, not with individual incomes.

8. Sickness could be imagined to influence the consumption variable as well, probably lowering it. This realistic but complicating feature is ignored in the theory. But the effects in practice, if any, should be picked up in the regressions of individual consumption on sickness to be described below.

9. Experimentation with positive subsistence points in consumption revealed these to be insignificantly different from zero for the most part, and they were subsequently dropped from the analysis.

10. It is conceivable that people migrate out of a village in bad times. We shall find out below if consumptions are optimally distributed for those who stay in residence. This does not preclude the possibility that consumptions dropped for

those who left, or otherwise moved in a way inconsistent with the risk sharing model. A partial attempt to measure the impact of migration on consumptions of residual claimants is reported below, namely by including number of family migrants as a potential explanatory variable in the consumption regressions.

11. This comes from the fact that consumption per unit age, not consumption alone, enters the objective function.

12. A rough check on the error terms indicated that this independence assumption was a good approximation to the data.

13. This is exact at any given date if "discontinuous" households are not added and there are no other terms in the regression equation.

14. The other independent variable on the right hand side of the benchmark regressions is the second order demographic term. This is no doubt also measured with error, but this is ignored here. The demographic variable turns out to matter little in any event. Measurement error in additional right hand side variables added to the benchmark would seem to cause the usual attenuation bias.

15. Again, one worries that the aggregate consumption variable has explanatory power only because it is a better indicator of individual incomes than the measured incomes in the sample. To control for this one might take differences in (17) (18) across households at a point in time, so that the aggregate consumption variable is removed. Alternatively, one might take the differences between each household and the sample average. This delivers the form of the cross section regressions reported below except that the difference between individual income and the sample average income is on the right hand side. Results are reported in Table 21 below.

16. In the case of logs, logged variables are set at zero if the log of the variable would have been negative or undefined.

17. It also fails to distinguish labor types. Female wages, for example, are significantly lower than males wages, and there is segregation in many work activities. Also, wages times leisure delivers an expenditure on leisure which is huge relative to expenditures on consumption, in the ratio of .95 to .05! Leisure seems to be counted too much and/or the wages used are too high.

18. These also show up in the time series regressions.

19. A separate but interesting project would be to make more systematic use of the time series of consumptions available from the dietary survey, along the lines indicated in this paper. The advantage of the dietary data is that it is available at the level of the individual.

20. One word of caution: the intercepts in the cross sectional regressions may also be bearing part of the movement in family size across households, so that the total effect in this data set may be larger than is indicated from the coefficient values of the alternative household size variables. It is possible to estimate the total effect more systematically by generalized least squares techniques, but this is not done here.

21. The coefficient value is the inverse of the risk aversion of the individual relative to the average of the inverse in the population.

22. This is based on preliminary data from 21 rain gauges placed in Aurepalle village in May, 1990 under a joint project of Rolf Mueller and this author with ICRISAT.

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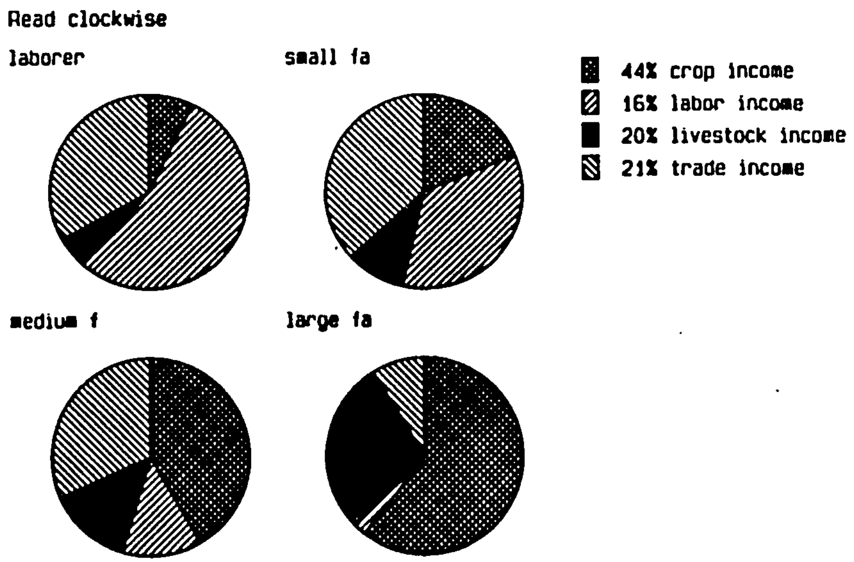


Figure 1: Composition of Income in Aurepalle

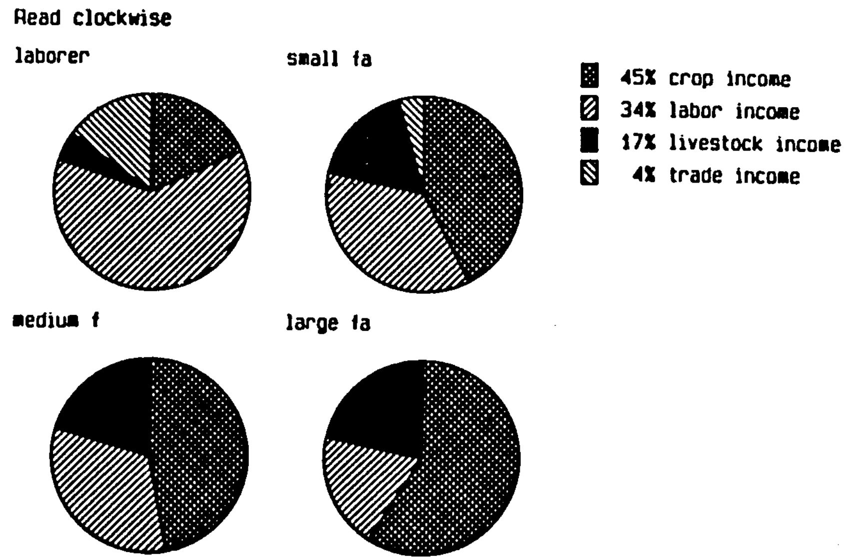


Figure 2: Composition of Income in Shirapur

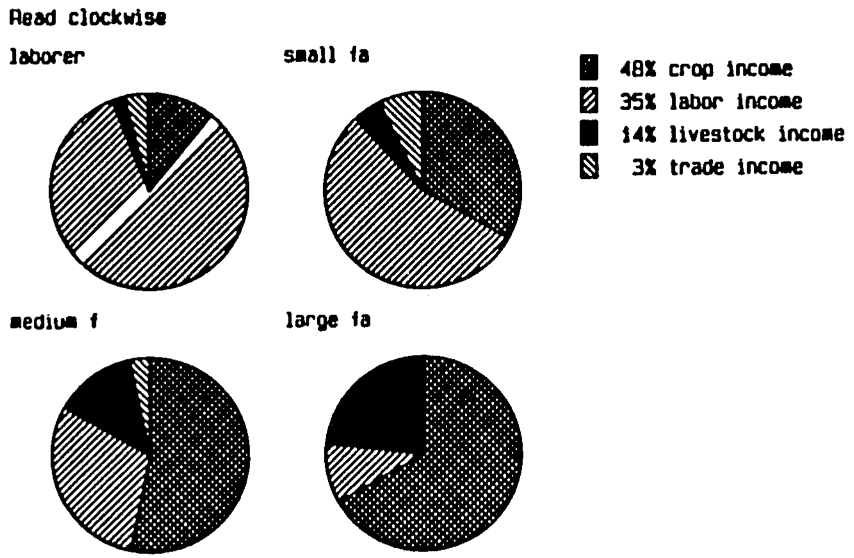


Figure 3: Composition of Income in Kanzara

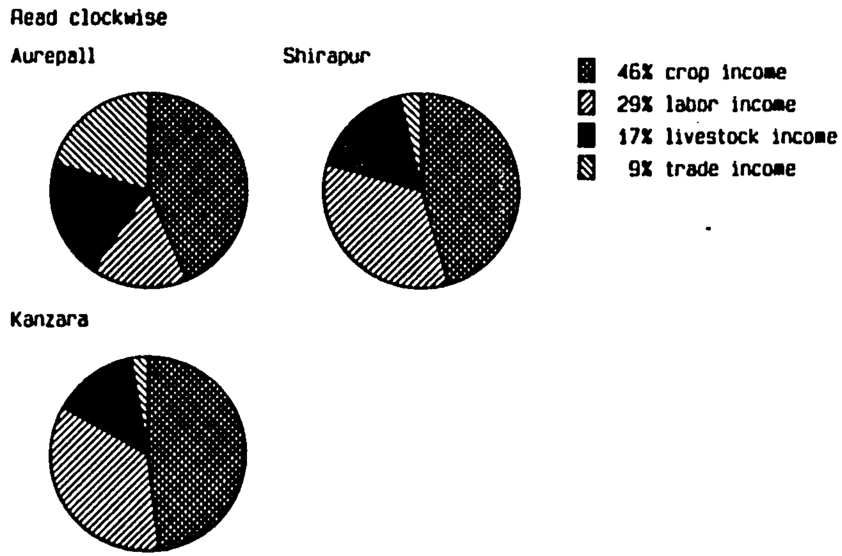


Figure 4: Composition of Income - All Villages Combined

Figure 5

Aurepalle

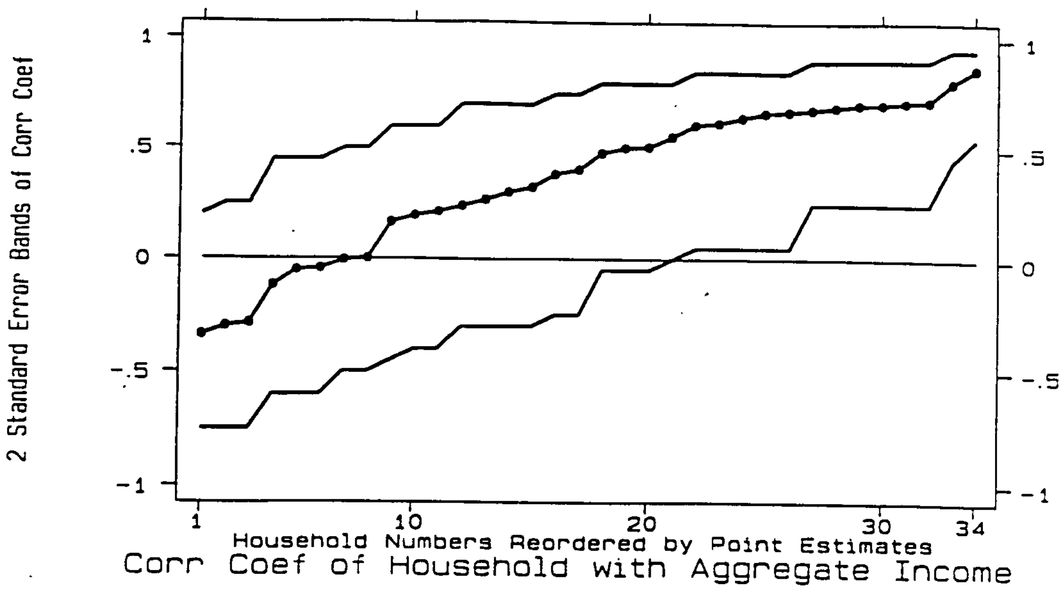


Figure 6

Shirapur

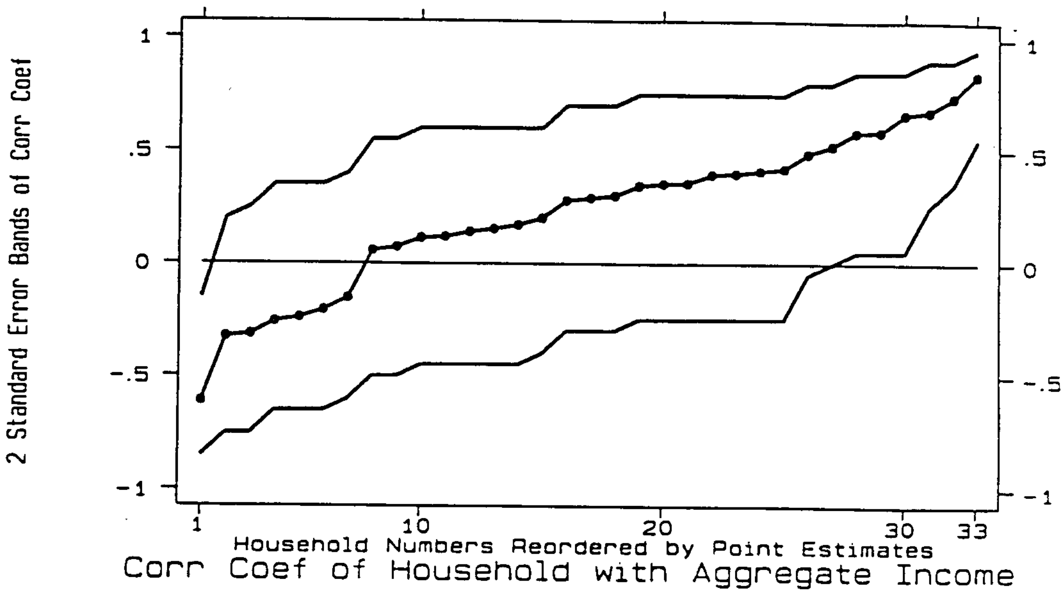


Figure 7

Kanzara

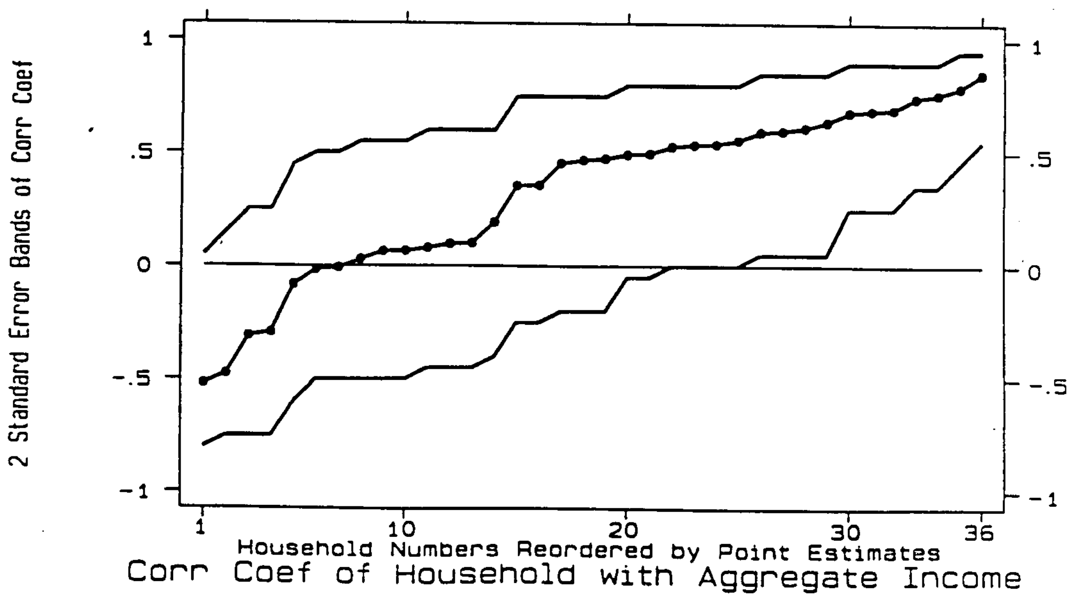


Figure 8

Comovement of

Household Incomes

-- Aurepalle

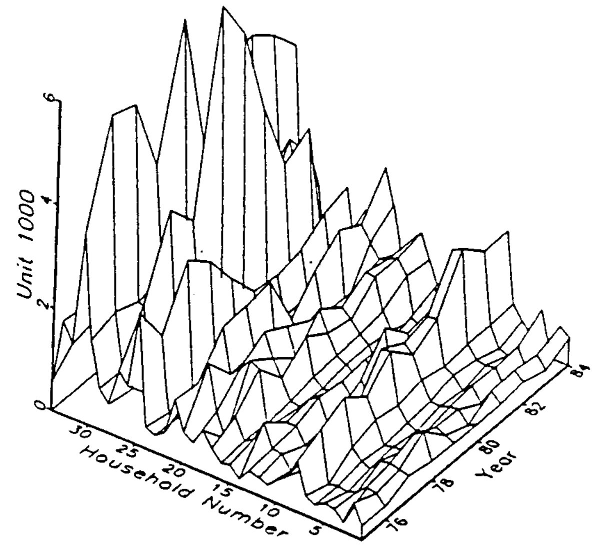


Figure 9

Comovement of

Household Incomes

-- Shirapur

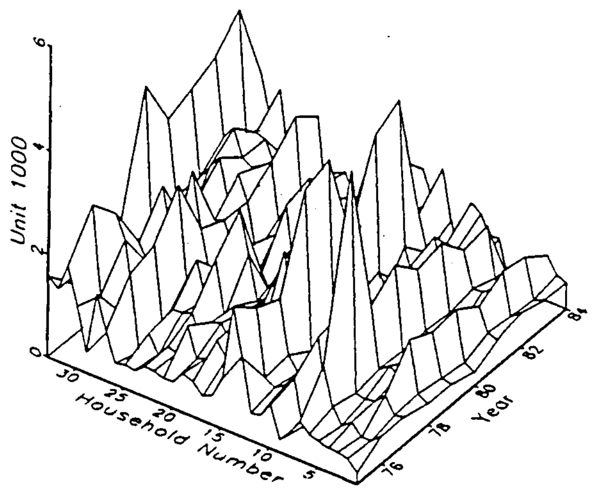


Figure 10

Comovement of

Household Incomes

-- Kanzara

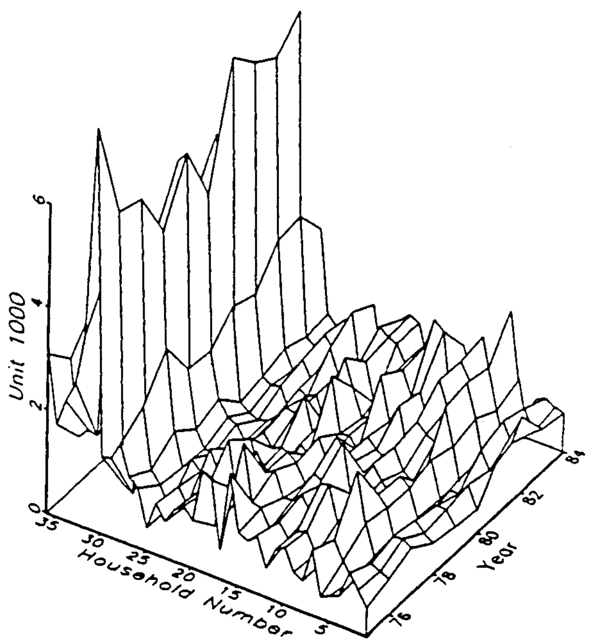


Figure 11
Comovement of
Household Consumptions
-- Aurepalle

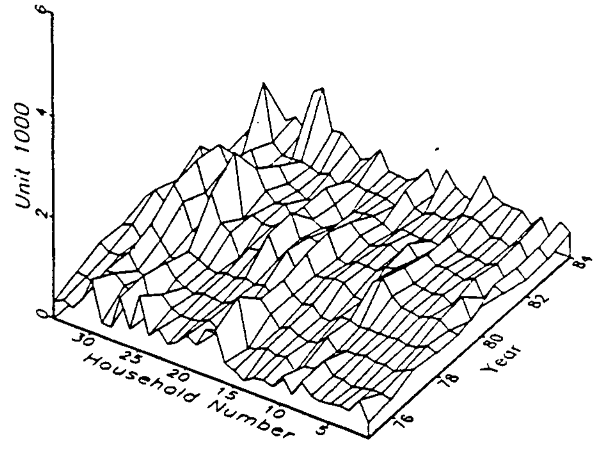


Figure 12
Comovement of
Household Consumptions
-- Shirapur

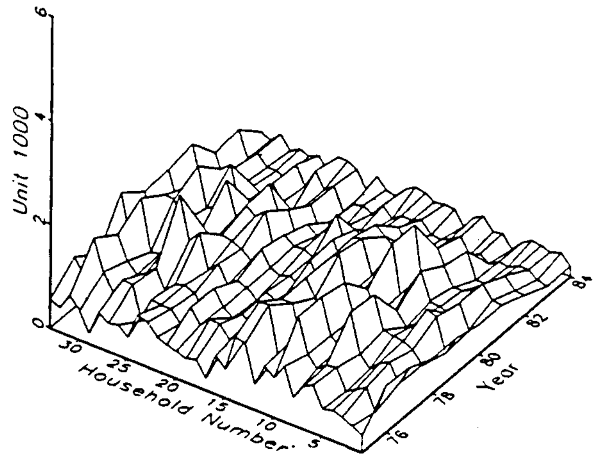


Figure 13
Comovement of
Household Consumptions
-- Kanzara

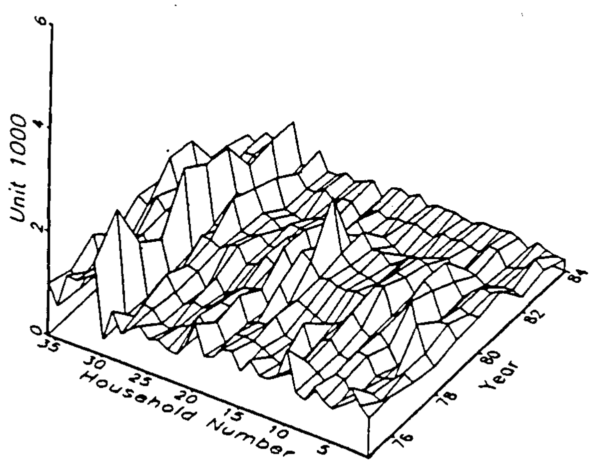


Figure 14

Aurepalle

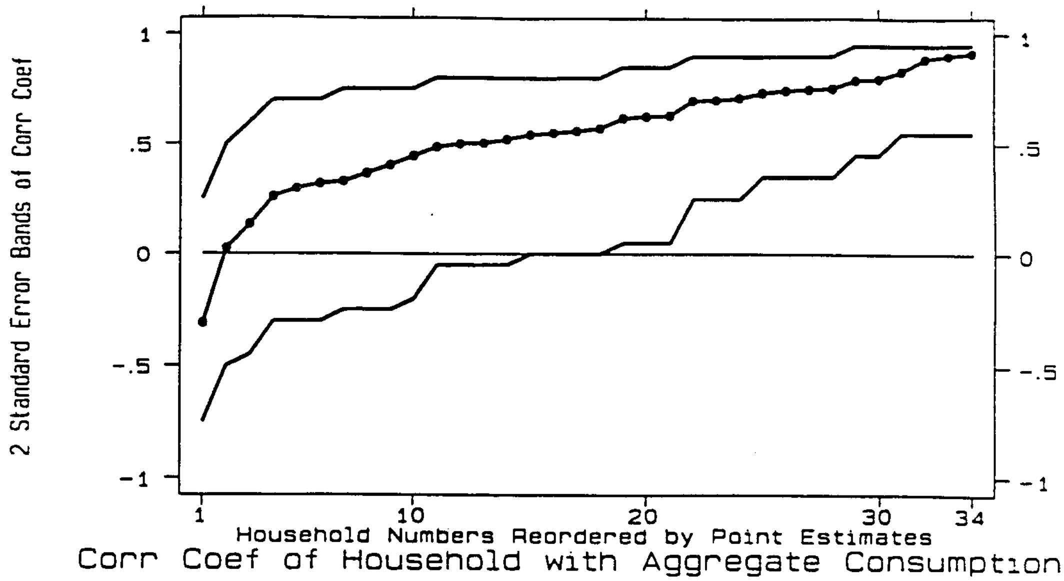


Figure 15

Shirapur

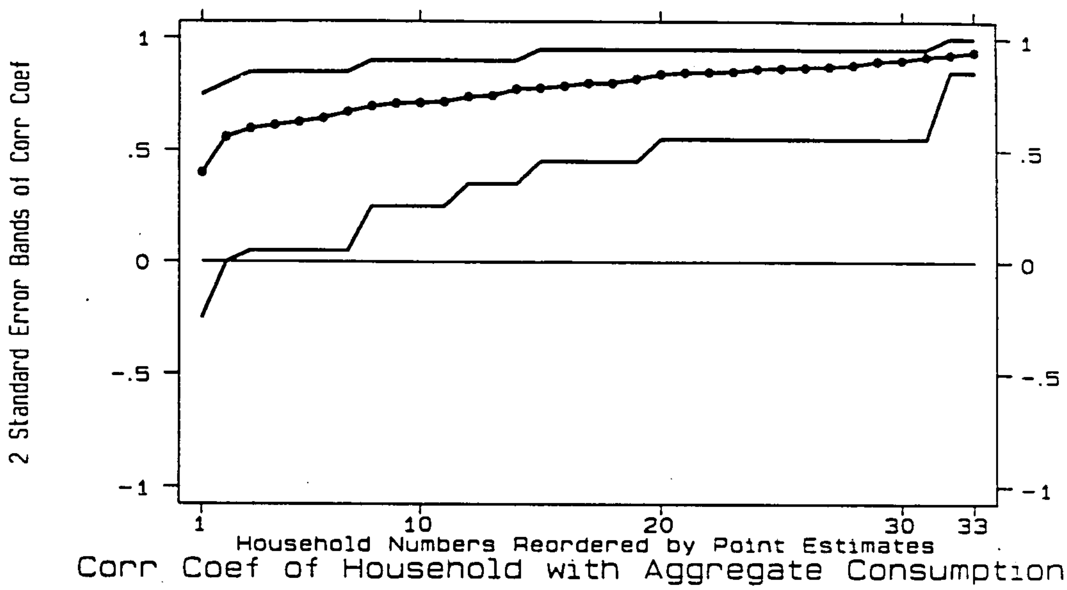


Figure 16

Kanzara

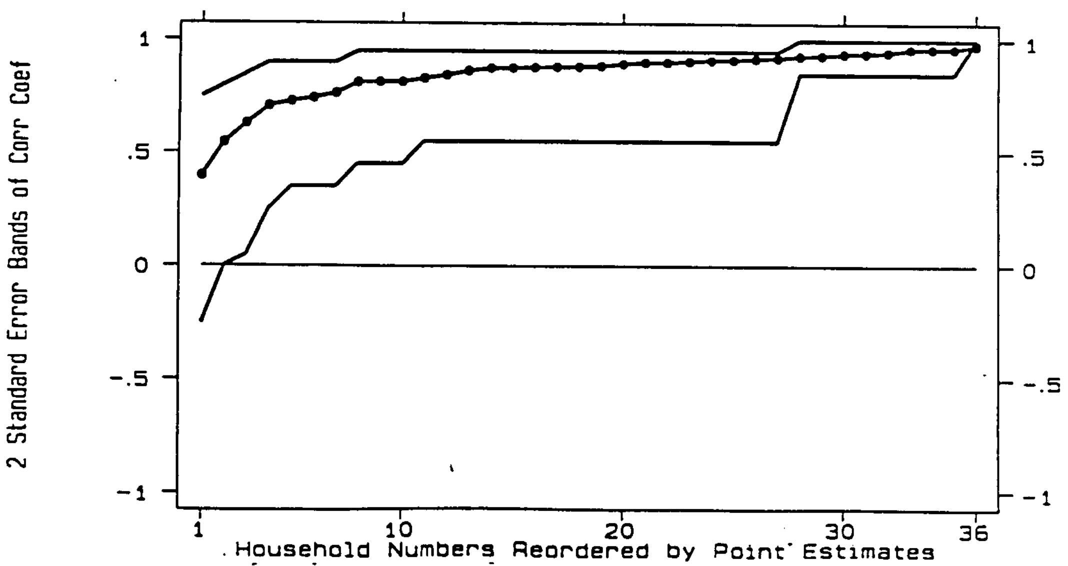


Figure 17

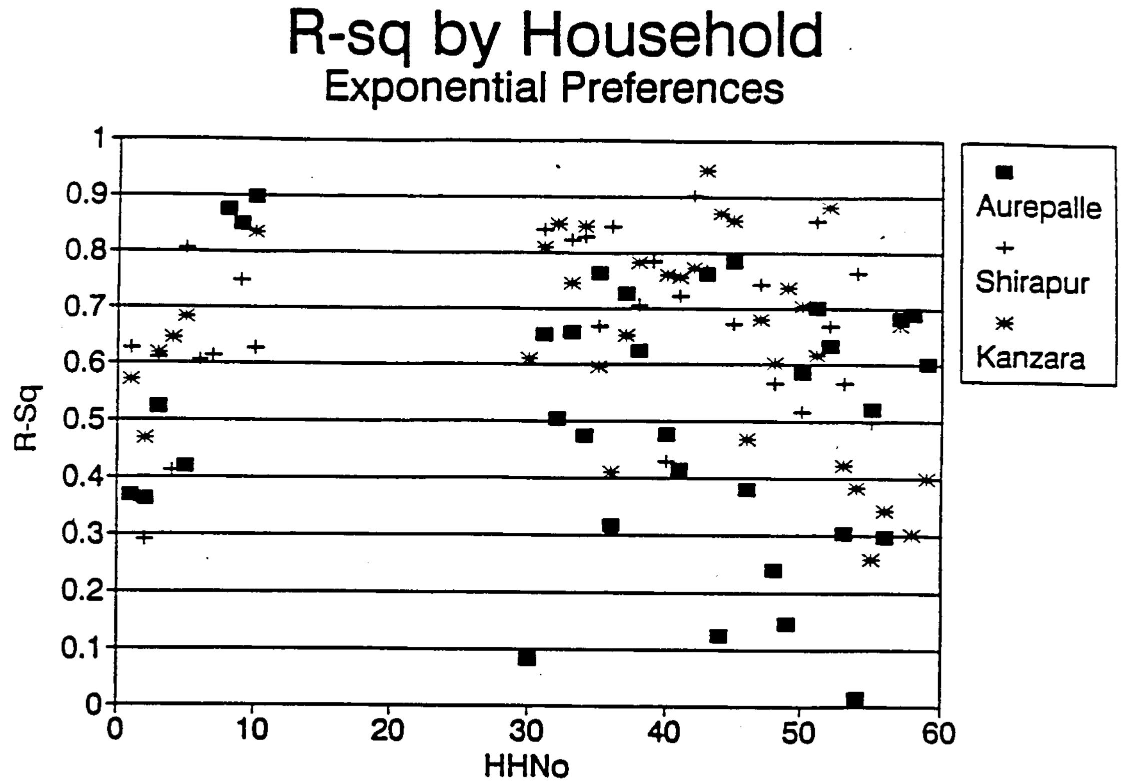


Figure 18

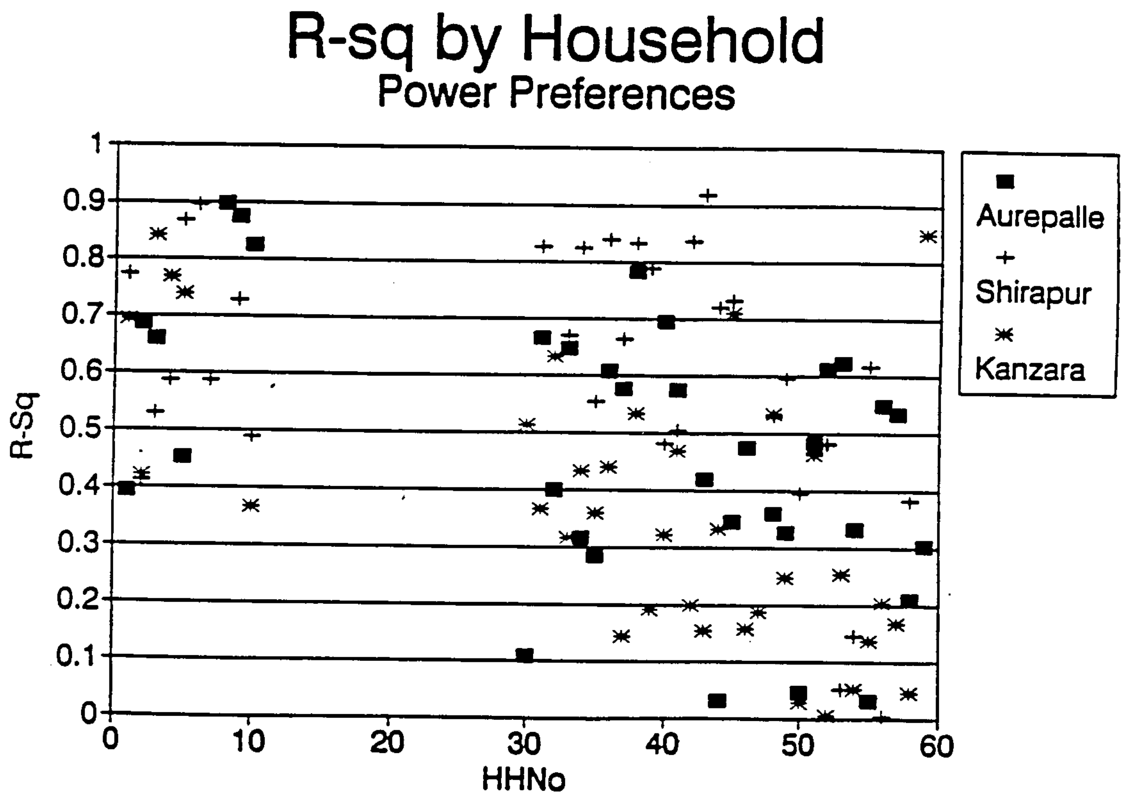
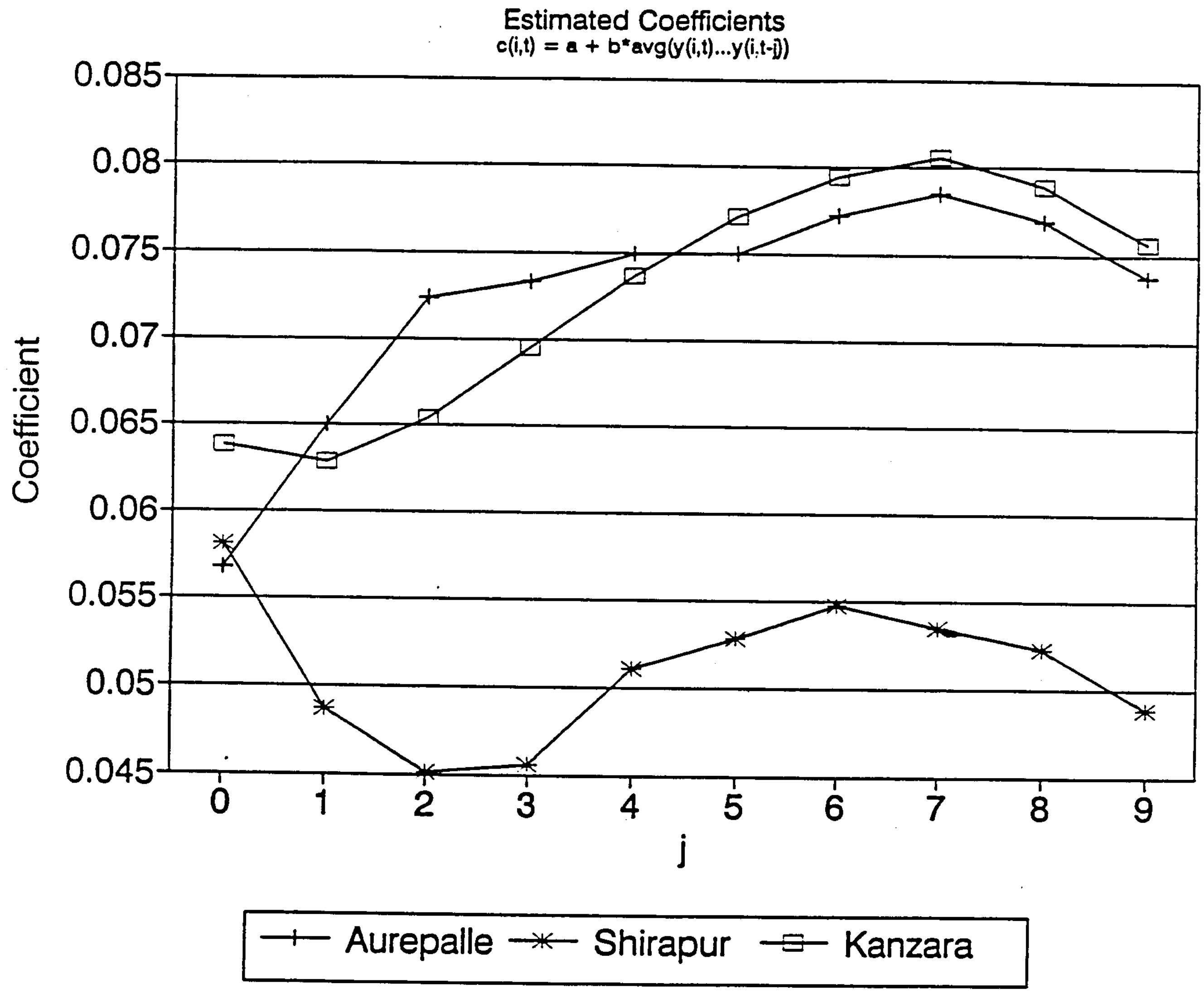


Figure 19



Estimated Coefficients
c(i,t) = a + b*avg(y(i,t)...y(i,t-j))
0.085
0.08
0.075
0.07
0.065
0.06
0.055
0.05
0.045
Coefficient
0
1
2
3
4
5
6
7
8
9
j
Aurepalle
Shirapur
Kanzara

Table 1

Coefficients of Variation and Correlation Across Dominant Crops

Aurepalle Kharif Season
Distinguishing Crops Ignoring Soil Types

Sorghum/Pearl Millet/Pigeonpea	Castor (not irrigated)	Paddy(combined traditional w/ HYV(irrigated)
0.5137 (0.1420)	0.8113 [0.45,0.95]	0.4983 [-0.05,0.80]
	1.0102 (0.3939)	0.0928 [-0.45,0.60]
		0.6974 (0.2190)

Table 2

Coefficients of Variation and Correlation of Castor Across Soil Types
Aurepalle
Distinguishing Soil Types

(6 obs) Medium Black Medium to Shallow Black	(9 obs) Shallow Red
0.7220 (0.2307)	0.3697 [-0.25,0.75]
	1.0142 (0.3965)

Table 3

Coefficients of Variation and Correlation Across Dominate Crops

Shirapur
Distinguishing Crops (Ignoring Soil Types)

Rabi Sorghum/ Safflower	Rabi Sorghum (local variety not irrigated)	Rabi All Pulses	Kharif All Pulses
0.5527 (0.1569)	0.5889 [0.05,0.85]	0.5047 [-0.05,0.80]	0.4862 [-0.05,0.80]
	0.3654 (0.0920)	0.6895 [0.25,0.90]	0.4891 [-0.05,0.80]
		1.0124 (0.3953)	0.1739 [-0.45,0.60]
			0.8797 (0.3140)

Table 4

Coefficients of Variation and Correlation of Sorghum Yields Across Soil Types
Sorghum (local Shirapur variety, Rabi not irrigated)

Distinguishing Soil Types

Deep Black	Medium Black	Medium to Shallow Black
0.6534 (0.1990)	-0.0460 [-0.60,0.45]	0.4396 [0.20,0.75]
	0.5303 (0.1482)	-0.0999 [-0.60,0.045]
		0.6466 (0.1959)

TABLE 5

TABLE BY MAJOR CROPS
AIREPALLE VILLAGE
YEAR 76

CROP

HOUSEHOLD NUMBER	SORGHUM/PEARL MILLET/PIGEON PEA CULTIVATED AREA IN ACRES/PERCENT		CASTOR (not irrigated) CULTIVATED AREA IN ACRES/PERCENT		PADDY(irrigated) CULTIVATED AREA IN ACRES/PERCENT		OTHERS CULTIVATED AREA IN ACRES/PERCENT		TOTAL FOR EACH FAMILY CULTIVATED AREA IN ACRES/PERCENT	
30	3	42.86	4	57.14	.	.	.	.	7	100.00
31	3	50.00	3	50.00	.	.	.	.	6	100.00
32	3	60.00	2	40.00	.	.	.	.	5	100.00
33	1	33.33	2	66.67	.	.	.	.	3	100.00
34	.	.	.	.	.	.	1	100.00	1	100.00
35	3	60.00	.	.	.	.	2	40.00	5	100.00
36	.	.	6	60.00	1	10.00	3	30.00	10	100.00
38	.	.	.	.	.	.	2	100.00	2	100.00
39	.	.	.	.	.	.	4	100.00	4	100.00
40	2	28.57	.	.	.	.	5	71.43	7	100.00
41	3	37.50	.	.	2	25.00	3	37.50	8	100.00
43	8	61.54	4	30.77	.	.	1	7.69	13	100.00
44	.	.	4	100.00	.	.	0	0.00	4	100.00
45	.	.	14	40.00	3	8.57	18	51.43	35	100.00
46	.	.	1	12.50	.	.	7	87.50	8	100.00
48	1	50.00	.	.	.	.	1	50.00	2	100.00
49	3	50.00	3	50.00	.	.	.	.	6	100.00
50	8	20.00	4	10.00	2	5.00	26	65.00	40	100.00
51	3	30.00	6	60.00	1	10.00	.	.	10	100.00
52	5	33.33	7	46.67	3	20.00	0	0.00	15	100.00
53	3	30.00	7	70.00	.	.	.	.	10	100.00
54	.	.	27	87.10	4	12.90	.	.	31	100.00
55	6	35.29	11	64.71	.	.	0	0.00	17	100.00
56	.	.	20	83.33	4	16.67	.	.	24	100.00
57	.	.	16	88.89	2	11.11	0	0.00	18	100.00
58	10	55.56	7	38.89	1	5.56	0	0.00	18	100.00
59	.	.	6	40.00	2	13.33	7	46.67	15	100.00
80	1	20.00	2	40.00	2	40.00	.	.	5	100.00

TABLE 6

TABLE BY MAJOR CROPS
SHIRAPUR VILLAGE
YEAR 76

CROP

HOUSEHOLD NUMBER	SORGHUM/ SAFFLOWER IN RABI CULTIVATED AREA IN ACRES/PERCENT		SORGHUM IN RABI (Local variety not irrigated) CULTIVATED AREA IN ACRES/PERCENT		SORGHUM IN RABI (Local variety irrigated) CULTIVATED AREA IN ACRES/PERCENT		ALL PULSES IN RABI CULTIVATED AREA IN ACRES/PERCENT		ALL PULSES IN KHARIF CULTIVATED AREA IN ACRES/PERCENT		OTHERS IN RABI CULTIVATED AREA IN ACRES/PERCENT		OTHERS IN KHARIF CULTIVATED AREA IN ACRES/PERCENT		TOTAL FO[R] FAM[I] CULTIVATE[D] IN ACRES/P[ERCENT]
31	1	16.67	2	33.33	.	.	1	16.67	1	16.67	0	0.00	1	16.67	6
32	.	.	5	62.50	.	.	1	12.50	.	.	1	12.50	1	12.50	8
33	.	.	5	71.43	.	.	1	14.29	.	.	0	0.00	1	14.29	7
35	1	14.29	3	42.86	.	.	1	14.29	1	14.29	1	14.29	.	.	7
36	12	54.55	8	36.36	.	.	1	4.55	.	.	1	4.55	0	0.00	22
37	.	.	2	100.00	.	.	.	.	.	.	.	.	.	.	2
38	1	4.00	8	32.00	.	.	1	4.00	.	.	7	28.00	8	32.00	25
39	.	.	1	50.00	.	.	0	0.00	1	50.00	0	0.00	.	.	2
40	.	.	14	58.33	1	4.17	.	.	2	8.33	1	4.17	6	25.00	24
41	.	.	0	0.00	1	12.50	2	25.00	3	37.50	1	12.50	1	12.50	8
42	.	.	2	14.29	.	.	.	.	2	14.29	.	.	10	71.43	14
43	2	11.76	3	17.65	.	.	.	.	5	29.41	5	29.41	2	11.76	17
45	3	33.33	1	11.11	.	.	0	0.00	2	22.22	0	0.00	3	33.33	9
47	.	.	8	72.73	.	.	1	9.09	2	18.18	0	0.00	.	.	11
49	.	.	4	28.57	.	.	0	0.00	10	71.43	.	.	.	.	14
51	.	.	0	0.00	.	.	4	14.81	1	3.70	16	59.26	6	22.22	27
52	1	3.23	12	38.71	1	3.23	.	.	15	48.39	1	3.23	1	3.23	31
53	.	.	6	25.00	.	.	3	12.50	8	33.33	.	.	7	29.17	24
54	.	.	4	20.00	.	.	0	0.00	6	30.00	6	30.00	4	20.00	20
55	.	.	2	9.09	.	.	2	9.09	2	9.09	12	54.55	4	18.18	22
56	.	.	15	62.50	.	.	.	.	3	12.50	1	4.17	5	20.83	24
57	13	38.24	13	38.24	.	.	0	0.00	8	23.53	.	.	0	0.00	34
58	7	18.92	12	32.43	.	.	1	2.70	5	13.51	1	2.70	11	29.73	37
70	.	.	1	14.29	.	.	2	28.57	.	.	0	0.00	4	57.14	7
80	.	.	0	0.00	1	20.00	.	.	.	.	3	60.00	1	20.00	5
90	.	.	2	50.00	.	.	.	.	2	50.00	.	.	.	.	4

Table 7
Coefficients of Variation and Correlations
Over Income Sources
Aurepalle

Profits from Crop Prod.	Livestock Income	Earned Wages	Trade & Handicraft
0.4227 (0.1101)	-0.0188 [-0.50,0.50]	0.5800 [0.05,0.85]	0.6297 [0.05,0.85]
	0.2136 (0.0499)	0.3607 [-0.25,0.75]	0.4586 [-0.20,0.75]
		0.4554 (0.1211)	0.8194 [0.45,0.95]
			0.4292 (0.1123)

Table 8
Coefficients of Variation and Correlations
Over Income Sources
Shirapur

Profits from Crop Prod.	Livestock Income	Earned Wages	Trade & Handicraft
0.2442 (0.0578)	0.5817 [0.05,0.85]	0.6386 [0.05,0.85]	0.7913 [0.45,0.95]
	0.1938 (0.0449)	0.2535 [-0.30,0.70]	0.6738 [0.05,0.85]
		1.3068 (0.6140)	0.7352 [0.35,0.90]
			0.3235 (0.0795)

Table 9

Coefficients of Variation and Correlation
Over Income Sources

Kanzara

Profits From Crop Prod.	Livestock Income	Earned Wages	Trade & Handicraft
0.4048 (0.1043)	0.8721 [-0.55,0.95]	0.8067 [0.45,0.95]	0.9345 [0.85,1.00]
	0.3830 (0.0974)	0.7436 [0.35,0.90]	0.8586 [0.55,0.95]
		0.5330 (0.1493)	0.8240 [0.45,0.95]
			0.2973 (0.0721)

Table 10

18 Male	1.0
18 Female	.9
13–18 Male	.94
13–18 Female	.83
7–12 Children	.67
4–6 Children	.52
1–3 Children	.32
1 Babies	.05

Table 11

Frequency of Significant Terms in Time Series Regression-
Levels
One Household at a Time

Benchmark Regression

	Aurepalle SIG	Aurepalle #	Aurepalle %	Shirapur SIG	Shirapur #	Shirapur %	Kanzara SIG	Kanzara #	Kanzara %
Intercepts	–	0	0	–	3	97.1	–	2	5.6
	0	33	97.1	0	26	81.2	0	34	94.4
	+	1	2.9	+	3	9.4	+	0	0
Village Consumption	<1	2	5.9	<1	2	6.2	<1	2	5.6
	=1	31	91.2	=1	29	90.6	=1	33	91.7
	>1	1	2.9	>1	1	3.1	>1	1	2.8
Age Diff.	–	1	2.9	–	3	9.4	–	1	2.8
	0	33	97.1	0	29	90.6	0	32	88.9
	+	0	0	+	0	0	+	3	8.3

Table 12

Frequency of Significant Terms in Time Series Regressions
Logs
One Household at a Time

Benchmark Regression

	Aurepalle			Shirapur			Kanzara		
	SIG	#	%	SIG	#	%	SIG	#	%
Intercepts	–	3	0.079	–	5	0.132	–	3	0.075
	0	34	0.895	0	32	0.000	0	35	0.875
	+	1	0.026	+	1	0.026	+	2	0.050
Village Consumption	<1	1	0.026	<1	1	0.026	<1	3	0.075
	=1	35	0.921	=1	34	0.895	=1	36	0.900
	>1	2	0.053	>1	3	0.079	>1	1	0.025
Age Diff.	–	2	0.053	–	3	0.079	–	1	0.025
	0	32	0.842	0	33	0.868	0	36	0.900
	+	4	0.105	+	2	0.053	+	3	0.075

Table 13

Tests for Insurance Against Idiosyncratic Income Shocks
Levels
One Household at a Time
Variables Entered One at a Time as Additions to Benchmark Regression

	Aurepalle			Shirapur			Kanzara		
	SIG	#	%	SIG	#	%	SIG	#	%
Labor Income	–	1	2.9	–	1	3.1	–	0	0
	0	28	82.4	0	28	87.5	0	34	97.4
	+	5	14.7	+	3	9.4	+	2	5.6
Crop Profits	–	2	5.9	–	1	3.1	–	0	0
	0	29	85.3	0	30	93.7	0	33	91.7
	+	3	8.8	+	1	3.1	+	3	8.3
All Income	–	3	0.088	–	1	0.031	–	0	0.000
	0	27	0.794	0	31	0.969	0	33	0.917
	+	4	0.118	+	0	0.000	+	3	0.083
Full Income	–	2	0.065	–	–	–	–	0	0.000
	0	28	0.903	0	–	–	0	30	0.857
	+	1	0.032	+	–	–	+	5	0.143
Wage	–	0	0.000	–	5	0.156	–	0	0.000
	0	33	0.971	0	26	0.813	0	33	0.917
	+	1	0.029	+	1	0.031	+	3	0.083

Table 14

Test for Insurance Against Idiosyncratic Income Shocks
Logs
One Household at a Time
Variables Entered One at a Time as Additions to Benchmark Regression

	Aurepalle			Shirapur			Kanzara		
	SIG	#	%	SIG	#	%	SIG	#	%
Labor Income	–	0	0.000	–	0	0.000	–	0	0.000
	0	30	0.882	0	29	0.879	0	32	0.889
	+	4	0.118	+	4	0.121	+	4	0.111
Crop Profits	–	0	0.000	–	3	0.091	–	3	0.083
	0	32	0.941	0	28	0.849	0	33	0.917
	+	2	0.059	+	2	0.061	+	0	0.000
All Income	–	1	0.029	–	1	0.030	–	1	0.028
	0	32	0.941	0	28	0.849	0	34	0.944
	+	1	0.029	+	4	0.121	+	1	0.028
Full Income	–	2	0.065	–	–	–	–	0	0.000
	0	28	0.903	0	–	–	0	31	0.861
	+	1	0.032	+	–	–	+	5	0.139
Wage	–	1	0.029	–	4	0.121	–	1	0.028
	0	32	0.941	0	28	0.849	0	34	0.944
	+	1	0.029	+	1	0.030	+	1	0.028

Count of Rejections of Full Insurance Against Income Shocks For Any Household and For Labor Income, Crop Profits, and All Income by Landclass and Village

Table 15
Levels

	Aurepalle	Shirapur	Kanzara
Landless	3	2	1
Small Farm	3	0	0
Medium Farm	1	1	3
Large Farm	1	1	1

Table 16
Logs

	Aurepalle	Shirapur	Kanzara
Landless	3	3	0
Small Farm	3	1	2
Medium Farm	1	1	5
Large Farm	2	2	1

Table 17

Pooled Cross-Sectional Regressions-Levels
Tests of Benchmark Against Alternative Variables
Entered One at a Time

Benchmark Itself

	Aurepalle		Shirapur		Kanzara	
Intercepts(-/+)	11/4		14/7		15/6	
Age Difference	-0.29	(15.41)	-35.33	(17.74)*	14.74	(13.13)

Coefficients on Alternative Variables Entered One At A Time
As Additions to Benchmark Regression

	Aurepalle		Shirapur		Kanzara	
Crop Output	0.053	(0.021)*	0.003	(0.004)	0.013	(0.011)
Profits	0.038	(0.024)	0.025	(0.032)	0.036	(0.019)
Labor Income	-0.044	(0.059)	0.130	(0.053)*	0.046	(0.032)
All Income	0.017	(0.009)	0.013	(0.011)	0.023	(0.010)*
Full Income	0.002	(0.003)	.	.	.006	.004
Wage	-1.134	(21.044)	103.266	(36.048)*	55.899	(29.831)
Sickness	-1111.268	(1306.739)	.	.	235.997	(303.031)
Unemployed	.	.	.	.	475.308	(520.656)
Not work	-833.770	(846.332)	.	.	190.000	(237.836)
Avg. Leis	0.031	(0.102)	.	.	0.031	(0.050)
Avg. Labor	0.149	(0.634)	.	.	0.031	(0.207)
HH Size	-16.261	(4.277)*	-16.209	(3.015)*	-10.192	(3.663)*
Adults	-12.722	(6.184)*	-26.195	(5.153)*	-6.543	(5.487)
Kids	-3.489	(3.985)	-7.662	(3.458)*	-1.419	(3.149)

Table 18

Pooled Cross-Sectional Regressions-Logs
Tests of Benchmark Against Alternative Variables
Entered One at a Time

Benchmark Itself

	Aurepalle		Shirapur		Kanzara	
Intercepts(-/+)	16/3		16/4		14/2	
Age Difference	0.10	(0.15)	0.26	(0.16)	0.08	(0.11)

Coefficients on Alternative Variables Entered One At A Time
As Additions to Benchmark Regression

	Aurepalle		Shirapur		Kanzara	
Crop Output	0.03	(0.01)*	0.00	(0.01)	0.00	(0.01)
Profits	0.02	(0.01)	0.01	(0.01)	0.01	(0.01)
Labor Income	0.01	(0.02)	0.10	(0.02)*	0.02	(0.02)
All Income	-0.00	(0.02)	0.16	(0.03)*	0.04	(0.03)
Full Income	0.00	(0.00)	0.04	(0.04)	-0.00	(0.04)
Wage	0.05	(0.06)	0.15	(0.07)*	0.14	(0.07)
Sickness	-0.15	(0.22)	.	.	-0.10	(0.08)
Unemployed	.	.	.	.	.	.
Not work	0.00	(0.29)	.	.	-0.08	(0.04)*
Avg. Leis	0.00	(0.01)	0.05	(0.06)	-0.01	(0.00)
Avg. Labor	0.00	(0.01)	0.11	0.12	-0.01	(0.01)
HH Size	-0.06	(0.02)*	0.04	(0.01)*	-0.03	(0.01)*
Adults	-0.19	(0.08)*	-0.36	(0.08)*	-0.04	(0.06)
Kids	-0.04	(0.04)	-0.04	(0.04)	-0.00	(0.03)

Table 19

Critical Significance Levels for Statistical Rejections of the Modified Benchmark Against a Set of Income Variables

Levels

	Aurepalle	Shirapur	Kanzara
Benchmark	0.17	0.11	0.00
w/Labor supply	0.02	0.08	0.17
w/HHsize	0.10	0.18	0.00
w/Both	0.06	0.08	0.19

Logs

	Aurepalle	Shirapur	Kanzara
Benchmark	0.11	0.00	0.05
w/Labor sup	0.13	0.00	0.06
w/HHsize	0.06	0.00	0.05
w/Both	0.08	0.00	0.06

Table 20

Benchmark With All-Income Distinguishing Landless Laborers From Farmers

	Aurepalle		Shirapur		Kanzara	
	Landless	Farmers	Landless	Farmers	Landless	Farmers
Village Consumption	.68 (.14)*	1.18 (.12)*	.92 (.08)*	1.06 (.07)*	.85 (.07)*	1.21 (.08)*
All Income	.09 (.10)	.04 (.02)	.18 (.05)*	.02 (.03)	.01 (.04)	.06 (.02)*

Table 21

Alternative Timing and Forms For Income Variables
Coefficient Values for Incomes in Cross-Section Regressions in Levels

	Aurepalle		Shirapur		Kanzara	
Household All-Income Minus Village Avg All-Income	.04	(.03)	.06	(.03)*	.06	(.02)*
All Income	.03	(.02)	.06	(.03)*	.02	(.02)
Last Year's All Income	.05	(.02)*	.06	(.02)*	-.01	(.02)
3-yr Avg All Income	.10	(.03)*	.10	(.04)*	-.03	(.02)

Table 22

Regression of Intercepts From the Cross-Section Regression
on Assets, Demograhic Variables
Levels

Coefficient Values - Std-Errors - R^2

	Aurepalle			Shirapur			Kanzara		
	Coefficient	Std-Error	R^2	Coefficient	Std-Error	R^2	Coefficient	Std-Error	R^2
Land	2.73	(.45)*	.50	1.53	(.63)*	.14	2.94	(.50)*	.48
Bullocks	.028	(.003)*	.71	.011	(.007)	.07	.019	(.003)*	.46
Inheritance	.0010	(.0001)*	.61	.00005	(.0003)	.001	.0004	(.0002)*	.08
Siblings	.02	(.24)	.02	-.16	(.25)	.01	.11	(.15)	.01
Married Sons	-.03	(.63)	.00	-.37	(.76)	.01	.10	1.67	.00
Migrants	2.04	(1.54)	.05	-.45	(.40)	.04	-.03	(.38)	.00

Coefficient Value-Critical Significance-R^2

	Coefficient	Crit-Sig	R^2	Coefficient	Crit-Sig	R^2	Coefficient	Crit-Sig	R^2
Age	-6.71	.50	.04	94.78	.04*	.16	161.29	.02*	.20
Age^2	.62			-12.17			-21.62		

Table 23

Regression of Intercepts From the Cross-Section Regression on
Assets, Demograhic Variables
Logs

Coefficient Values - Std-Errors - R^2

	Aurepalle			Shirapur			Kanzara		
	Coefficient	Std-Error	R^2	Coefficient	Std-Error	R^2	Coefficient	Std-Error	R^2
Land	4.80	(1.20)*	.31	3.44	(1.71)*	.10	5.51	(1.58)*	.24
Bullocks	.63	.15*	.34	.18	.21	.02	.47	.25+	.09
Inheritance	.36	(.14)*	.16	.17	(.15)	.02	.38	(.17)*	.11
Siblings	.44	(.77)	.01	-.13	(.92)	.00	.39	(.81)	.00
Married Sons	-1.38	1.69	.05	.18	(1.61)	.00	1.72	3.28	.06
Migrants	.0	.0	.0	-1.35	(.76)	.61	-.31	(2.44)	.00

Coefficient Value-Critical Significance-R^2

	Coefficient	Crit-Sig	R^2	Coefficient	Crit-Sig	R^2	Coefficient	Crit-Sig	R^2
Age	-6.71	.50	.04	94.78	.04*	.16	161.29	.02*	.20
Age^2	.62			-12.17			-21.62		

Table 24

Rejections of Constant Intercepts with Sample
Split into Two 5-Year Periods
1 = Rejection

	Levels			Logs		
HH#	Aurepalle	Shirapur	Kanzara	Aurepalle	Shirapur	Kanzara
1					1	
2		1		1		1
3					1	1
4						
5			1			
6						
7			1			
8			1			
9				1		
10				1		
30		1				
31		1		1		
32				1		
33				1		
34				1		1
35		1				
36		1		1		
37						
38						
39					1	
40				1		1
41				1		1
42						1
43				1	1	1
44						1
45						1
46				1		
47						
48				1		
49					1	
50						
51		1		1		1
52	1					1
53			1	1		
54			1		1	
55	1	1				
56	1				1	
57						
58		1				1
59						
Total	3	8	5	15	7	12