KEELE UNIVERSITY

Inaugural Lecture†

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1 A Tale of Three Villages

I'll start with a tale of three village communities, one from India, one from Africa and one from Asia. Poovar and Purakkad are small fishing villages in Kerala state in southern India. The fishermen of these villages have a choice either of beach-seining or going deep-sea fishing with lines on non-motorized boats. They fish when the weather permits and when there is evidence of fish which means that on average they fish every second or third day. When they fish, they land and market their catch on the beach. There are large day-to-day variations in the catch of any one fishing team and large variations in catches across different teams on any given day. Some teams will be lucky and happen upon good shoals of fish and land good catches and others will be less fortunate and net only a meagre haul. But the chances are that the luck will even itself out and those fortunate today may be less fortunate tomorrow. The response of the fishermen to the variability in their catch is documented by Jean-Phillipe Platteau of Namur University in Belgium (see Platteau and Abraham [57] and Platteau [58]). Those fishermen who have been unlucky enough to have a bad catch are able to borrow interest-free from those who have been more fortunate. This system of credit is very active with each fisherman undertaking a loan or borrowing or making a repayment on average every other day. It also appears to be very effective in reducing the variability of consumption relative to the variability in their income.

The Basarwa of northern Botswana are semi-nomadic subsistence farmers who grow mainly maize and sorghum. They own relatively few animals and borrow *mafisa* cattle from wealthier cattle owners. The basarwa get the milk and draught power of the mafisa cattle (and possibly any calves) but must return the animal after the season. They stay in one place only for a few seasons and then move usually in order to borrow new mafisa cattle. They face important sources of variation in their crop yields from regional drought, crop disease and pests. The pests are clearly an important worry. As one of the Basarwa put it: the cattle eat and destroy the crops, the birds eat the sorghum, the monkeys eat the maize, the jackals eat the watermelon and duikers eat the beans. The Basarwa have been studied by the anthropologist Elizabeth Cashdan (see Cashdan [14]) who finds that there is widespread evidence of food-sharing amongst the Basarwa with gifts mainly of meat but also grain and milk given to those in need. Small gifts are also given frequently "to reinforce the social relationships that can be called upon for more significant gifts should the need arise". This system of reciprocal giving helps stabilise food consumption and is a "cost-effective way of attaining security for this population".

The rice terraces in the Cordillera mountains of northern Luzon island in the Philippines are justifiably famous and the mountains are home to many isolated rice-farming villages. Susan Lund and Marcel Fafchamps of Stanford University [46] report on a survey of four villages in the area.[1] All 206 households in the survey participated in gift-giving or receiving in the 9 months of the survey and the majority also participated in giving or receiving of loans. Over 80% of these transactions were between households within the same village and virtually all others were with adjacent villages. Nearly all expected to transact with the same partner again. Over half the households reversed their roles with their loan partner within the 9 month survey period. So debtors became lenders and visa-versa. Most of the loans and gifts were for consumption purposes. None of the loans were written down, less than 3% specified a repayment schedule, only 1% required collateral and over 80% were interest-free. Of the loans repaid within the survey period nearly 20% were *not* repaid in full. In only one case did the lender claim that a default had taken place. In all other cases the borrowers and lenders agreed to forgive part of the loan due to the borrowers' difficult circumstances.

2 Outline

These three studies illustrate what I mean by informal insurance arrangements and what I mean by village economies. The gifts, loans and transfers between the villagers are predominately for consumption purposes;[2] they provide some insurance against a bad catch or a bad harvest but are informal as there are no written records; no legal procedures to enforce repayments; no collateral; and an understanding that debts may be delayed or forgiven if circumstances dictate. The village economy is some relatively small, relatively closed, relatively cohesive, near subsistence, agricultural economy.

I'm going to talk about some recent work that I've been doing with Jonathan Thomas of Warwick University and Ethan Ligon from the University of California at Berkeley, which is largely contained in [43].

Now village economies might be thought to be the preserve of economic and social anthropologist who indeed have done many and detailed study of life in rural villages.

[1]This survey is probably unique as it was explicitly designed to gather information on gifts, loans and transfers.

[2]Informal arrangements are also used for the financing of productive investments and indivisible goods. A common approach is the use of rotating savings and credit associations (Roscas), see [6]

There has also been considerable discussion of informal insurance arrangements (see e.g. [13]). So why do I think we as economists have something to contribute to this study? Well the one thing that this literature emphasizes is that life in village economies is aleatory. Risk is the predominant fact of life. Risk to crops from poor weather or disease or pests, the risk of losing ones animals and the risk of illness. James Scott starts his book on "the moral economy of the peasant" with a quote from R. Tawney "the position of the rural population is like a man standing permanently up to the neck in water, so that even a ripple is sufficient to drown him". Risk and the allocation of risk something economists do know about, so I think and hope to convince you that we can make a contribution here.

What we do is adopt a very deductivist methodology. That is we ask, suppose we were in the situation faced by the fisherman in Poovar or Purakkad, knowing more or less what the risks are and knowing that if someone fails to repay there are no courts to enforce the payment, how would we best design an arrangement that provides as much insurance as possible in these circumstances. I'll give an example in a minute. We then find what this *efficient* arrangement is and compare it with actual data. If the fit is good then the theory provides a reasonable approximation and we can use the theory to make predictions about policy interventions or other changes. If the fit is bad, then the theory should be refined or abandoned. What I will argue is that our theory is consistent with the observations. I'll hope to convince you that it is part of the explanation for observations of informal insurance arrangements. I'll then explain the theory and predictions in a bit more detail and show how the theory is used in our empirical work and argue that it performs better than any of the alternatives.

Let me first just contrast this with the inductive approach, which *starts* with observations about what informal arrangements are used and then develops a model to explain the observations. Both approaches are useful and economists have certainly succesfully used both approaches. I think most work use a little bit of both methodologies. Our current work happens to be very deductivist in nature.

I don't have strong opinions as to which is the best approach to adopt. Each has advantages and disadvantages. The advantage of the deductivist approach is that it forces one to be very explicit about the economic environment. The disadvantage is that it doesn't help us understand how institutions evolve as a response to the problems faced. Rather it assumes that the institution exists to solve a given economic problem.

3 Why study village economies?

Before I give an example of our deductivist approach I want to answer the question of why in general it is important to study village economies. It might be thought that the study of village economies is somewhat of a backwater of the profession. It is not true. I want to argue that it very firmly in the mainstream. Witness the considerable interest in village economies taken by economists over recent years. The pioneering work of Bliss and Stern [10] deserves special mention but there are many others (see Taylor and Adelman [74], Dréze and Sen [21], Hoff, Braverman and Stiglitz [36], Townsend [78] and Bardhan [3]).[3]. Moreover, I wish to argue that the study of village economies is of huge practical relevance to the economics of development and can play a central role in the development of economics.

First and most obviously three quarters of the world live in the less developed countries and nearly one-half of the world live in small rural communities. The one-sixth of the world's population who are amongst the poorest and most needy live in the unpredictable climate of the semi-arid tropics. There is perhaps no more important topic in economics and perhaps in the social sciences than understanding why some communities are poorer and develop more slowly than others. It is hard to conceive of any other area where improvement in policy could have such a large and beneficial impact. To put it another way: the study of small economies is one of the big questions perhaps even the biggest.

Secondly, previous policy interventions have been only moderately and patchily successful such as the green revolution and others have at best proved only partially successful and at worst have been counter-productive. For example the widespread introduction of subsidized rural credit in the 1960s and 1970s did not achieve its objective of increasing productivity and reducing poverty. Indeed there is evidence that the distribution of income worsened with only a small faction 5-15% of potential borrowers getting loans and 5% of the borrowers getting 80% of the credit (see Braverman and Guasch [12]). Even the more recent and interventions like the Grameen Bank in Bangladesh or the BKK in Java which have been successful in there own terms of promoting savings have been questioned as to whether they have actually improved welfare (see [80]). There is an obvious worry that official programs will "crowd out" or replace informal institutions and not necessarily lead to welfare improvements. It is therefore important to understand the

[3] Anthropologists have of course long studied village economies and there have been occasional forays of collaboration between anthropologists and economist, e.g. [24]

existing informal institutions and how they may interact with any new institutions if one is to evaluate current policy or advocate new ones.

Thirdly and at a less esoteric level Joe Stiglitz has said that the study of village economies and less developed countries in general is to the study of economics, what pathology is to the study of medicine. By understanding what happens when things work badly we gain insight into how they work when they function well. The study of village economies may then also be extremely important to the profession in general. There are actually two reasons why this is so. One is because village economies are simple economies and the other is because village economies are complex economies.

The simplicity is perhaps obvious: a village economy is, as I've defined it, a relatively small relatively closed economy, the number of goods is limited, there are only a few types of agents, landlords, tenant-farmers, landless-labourers etc., the technology is relatively simple and the set of decisions each villager has to make relatively small, when and what to plant etc. From this perspective they are easier to study than large and complex industrial economies.

On the other hand village economies are extremely complex. The complexity arises because there does not exist a complete set of contingent claims markets as there would in the Arrow-Debreu model found in standard economics textbooks. Thus for example the standard Fisher separation theorem which implies that consumption and production decisions can be made independently does not apply. The Fisher separation theorem is the first thing we teach our Finance principal students. To illustrate it, suppose a shopkeeper is thinking of expanding and opening a second shop at the other end of town. He has the money to do it but is thinking whether he shouldn't really spend the money on that Porsche he has always wanted. The point of the Fisher separation theorem is that such considerations are irrelevant. If the new shop is going to be profitable, he can borrow the money to open the shop and repay the loan out of the profits and still have his new Porsche now. Of course this is only an approximation, borrowing and lending rates need not be exactly the same, but it is an approximation that works reasonably well in an industrialized society. In a rural community in a less developed country it is inappropriate. Farmers cannot borrow and lend at a given rate of interest, there is no market for equity or a market for crop insurance. Consumption and production decisions cannot be separated and the maximization of net present value does not apply (rationality and profit maximization do not go hand-in-hand, see Lipton [45]). Resources are allocated not by markets but by non-market institutions that act as partial and imperfect substitutes for the absent or missing markets. This means that the relevant economic theory necessary to study village economies is the advanced theory on missing markets developed over the last two decades using techniques from game theory and mechanism design. Simple economies require sophisticated economics.

Fourthly and relatedly, there is also a methodological point made in particular by Rashid and Townsend [64] that we should view abstract theory and down-to-earth empirical work as complements and not substitutes. The idea is that to evaluate any policy one needs to iterate from theory to data and back again. That is one starts with a deductive methodology and tests the theory to see where it is deficient. One then refines the theory and if necessary collects appropriate data and tests the theory again. The point made by Townsend is that village economies being relatively simple are more like our simplified models, few number of goods and simple technology etc. and that any new data can be collected relatively quickly. In this way, village economies provide a good laboratory for this methodology as the process of iteration between theory and data can be most effectively and quickly accomplished for simple economies.

4 Examples

Consider the following example. Each household has an income of either 1000 with probability $(1-p)$ or 500 with probability p. These draws are independent so the probability that both households get 500, for example, is p^2. Now consider a scheme where if the incomes are different, the household with the high income transfers an amount $0 \leq x \leq 250$ to the low income household. We can ask whether it is in the household's interest to make such a transfer given that it expects the other household to reciprocate. Suppose that each household has a utility function $u(c)$, where c is consumption, which has positive but diminishing marginal utility. The short-run gain from making the transfer is

$$u(1000-x)-u(1000)$$

which is of course negative for $x > 0$ indicating a loss. The potential long-term gain from such an arrangement is

$$\frac{\delta}{(1-\delta)}\{p(1-p)(u(500+x)-u(500))\}+\frac{\delta}{(1-\delta)}\{p(1-p)(u(1000-x)-u(1000))\}$$

where $0 < \delta < 1$ is the discount factor which measures the trade-off between current and future income. Since marginal utility is diminishing,

$$u(500+x)-u(500) > u(1000-x)-u(1000)$$

Harvest	1's yield	2's yield	Transfer 1 to 2	1's share	2's share
418	1000	1000	0	0.5	0.5
419	1000	500	177.1	0.5486	0.4514
420	1000	1000	0	0.5	0.5
421	1000	500	177.1	0.5486	0.4514
422	1000	1000	0	0.5	0.5
423	1000	1000	0	0.5	0.5
424	500	1000	-177.1	0.5486	0.4514
425	500	500	0	0.5	0.5
426	1000	500	171.1	0.5486	0.4514
427	1000	1000	0	0.5	0.5

Table 1: Static Transfer

and the long-term gain in the equation above is positive. This simply reflects the fact that there are gains to risk-pooling. They will be larger the greater the curvature of the utility function or the more risk averse is the household. The long-term gains are also increasing in x and δ and are greatest for $p = \frac{1}{2}$. The short-term gain is decreasing in x.

Ideally the outcome should be $x = 250$ where each household gets an equal share of aggregate income. This is the full insurance outcome. Depending on the probabilities and the discount factor however, the full insurance transfer of 250 may not be sustainable as the short-term loss will exceed any long-term benefits. As an example, suppose δ=20/21 which corresponds to a discount rate of 5%, $p = 0.1$, and that the utility function is logarithmic. Then the short-run gain is -0.2877 and the long-term gain is 0.2120. Thus it is not worthwhile making a transfer of 250.

It may be worthwhile if x were smaller and a simple calculation shows that the long-term gains offset the short -term losses for x<177.1. The maximum risk-pooling that can be achieved given that the long-term benefits should exceed any short-term costs is x=177.1. This solution is what is called the static limited commitment solution and is that outlined in the paper by Coate and Ravallion [15]. It is static because if the distribution of income is the same, then the same transfers are made. It is a limited commitment solution because transfers are only made when the benefits exceed the costs: no household can commit to make a larger transfer as such a commitment would not be credible — the household would never find such a transfer beneficial. The results of a particular simulation is shown for a few periods in Table 1. The absence of commitment implies that the relative shares are no longer constant over time.

The static limited commitment solution might be interpreted as a system of gift-giving or sharing when the need arises. The evidence from the villages of Kerala state, northern Botswana, the Philippines and elsewhere is that loans for consumption purposes are much more common. That credit can and is used as insurance has long been recognized (see e.g. Eswaren and Kotwal [22]). That is borrow when times are bad and repay when times are good.[4] These loans may however, be interpreted better as a type of quasi-credit as they have an implicit rather than an explicit repayment.[5] It may be quite puzzling why these quasi-credit arrangements are used in place of or as a supplement to gifts. In the context of limited commitment however, the benefits of the quasi-credit element becomes clear. Suppose that the transfer is increased by a small amount say one unit and in return there is a *repayment* of R next period if both households have 1000. The current marginal gain to the transferee is $u'(500 + x)$ and the marginal loss from next period's repayment is $\delta(1 - p)^2 u'(1000)R$. The current marginal loss to the transferer is $u'(1000 - x)$ and the marginal gain from next period's repayment is $\delta(1 - p)^2 u'(1000)R$ the same as the transferee's loss. As marginal utility is diminishing $u'(1000 - x) < u'(500 + x)$ for x<250 so it is possible to choose R in such a way that both transferer and transferee gain, that is when R is chosen so that

$$\frac{u'(1000 - x)}{\delta(1 - p)^2 u'(1000)} < R < \frac{u'(500 + x)}{\delta(1 - p)^2 u'(1000)}$$

The intuition is simple. By demanding a repayment the transferer has an incentive to make a larger transfer and this helps risk-pooling which is to everyone's benefit. Exactly how the loans and repayments are optimally arranged is discussed later but the optimal solution in the example with logarithmic utility and δ=20/21 and $p = 0.1$ is illustrated in Table 2. It can be seen from the table that the shares of income are less variable than in Table 1. To examine the variability in shares more generally, I'll present some results from a more complicated simulation.[6] A random sample of nine income was drawn from a lognormal distribution with a mean and variance matching that in the data from the villages in rural India discussed in Section 7. It was assumed that the two households have identical and independent income draws, so there are a total of 81 states. The solutions were computed and income simulated over 600 periods. The results for 50 periods are

[4]Udry [81] finds evidence from northern Nigeria that repayments on loans are state contingent. On average a borrower with high income repays 20.4% more than he borrowed but a borrower who has another bad year repays 0.6% less than he borrowed. Moreover repayments are contingent on the lender's position. A lender with a good realization of income receives on average 5% less than he lent, but a lender with a bad realization receives on average 11.8% more

[5]The idea that repayments should be made state contingent when there are enforceability problems is a familiar one in the context of the sovereign debt literature (see e.g. [39], [31] and [83]).

[6]Details of the computation and simulation procedure can be found in Section 12

Harvest	1's yield	2's yield	Transfer 1 to 2	1's share	2's share
418	1000	1000	-16.59	0.5083	0.4917
419	1000	500	237.56	0.4917	0.5083
420	1000	1000	-16.59	0.5083	0.4917
421	1000	500	237.56	0.4917	0.508
422	1000	1000	-16.59	0.5083	0.4917
423	1000	1000	-16.59	0.5083	0.4917
424	500	1000	-237.56	0.5083	0.4917
425	500	500	8.29	0.4917	0.5083
426	1000	500	237.56	0.4917	0.5083
427	1000	1000	16.59	0.4917	0.5083

Table 2: Dynamic Transfers

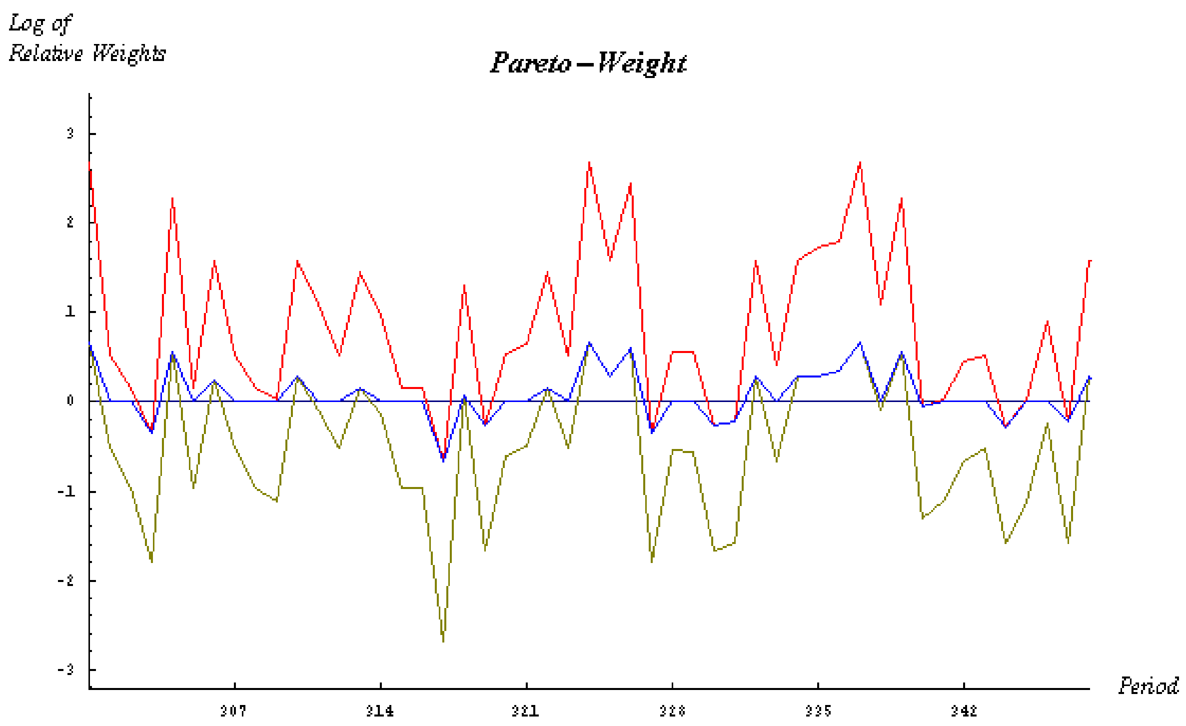

Figure 1: Relative Shares — Static Limited Commitment

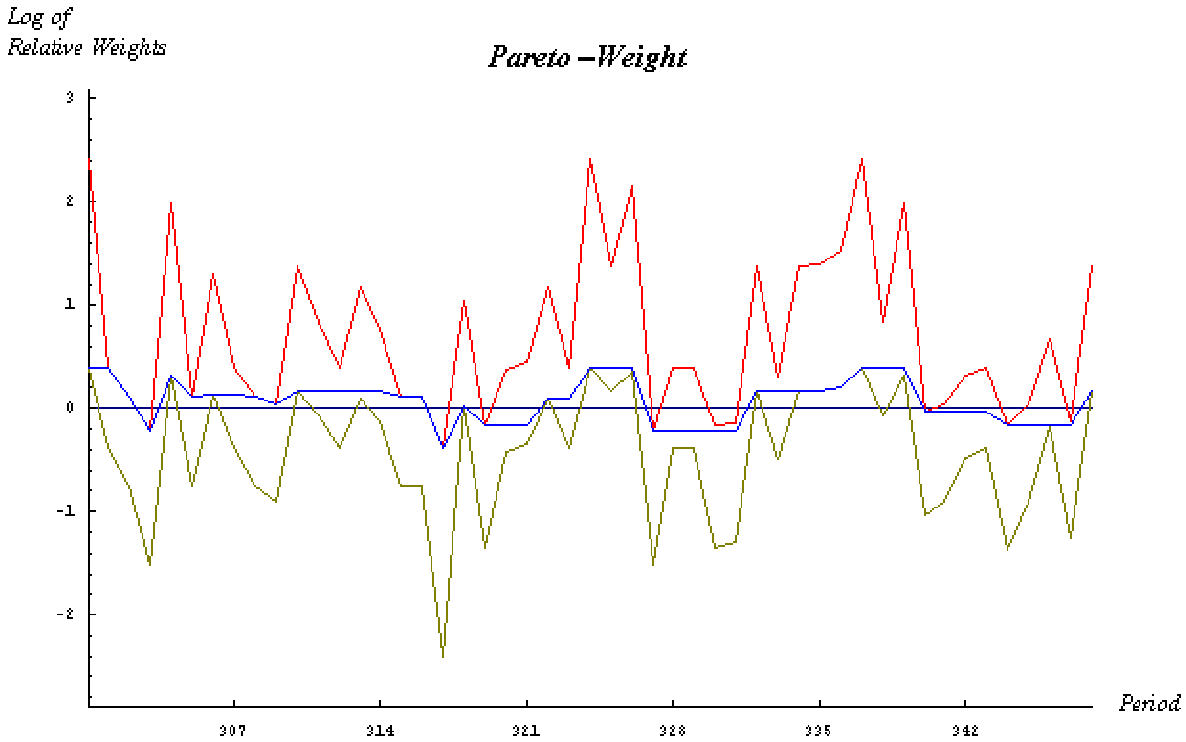

Figure 2: Relative Shares — Dynamic Limited Commitment

displayed in Figure 1 and Figure 2. The vertical axis plots the logarithm of the relative shares of the two households. Thus a value of 0 represents equal shares and positive values indicate that household 1 has the larger share. The middle/blue line indicates the actual shares and the red/top and brown/bottom lines indicate the theoretical limits. These are theoretical limits. It is perfectly possible for the relative share to exceed or fall below these bounds. It is just never optimal to do so. In the static limited commitment case (Figure 1) the middle/blue line returns to the horizontal axis when possible but is otherwise at one of its bounds. In the dynamic limited commitment case (Figure 2) two things are different. The theoretical bounds are smaller and the middle/blue line doesn't revert to the horizontal axis but stays constant between the bounds if it can. Looking Figure 2, it is easy to see the general rule for the relative shares: keep the relative share constant if doing so keeps it within the theoretical bounds, otherwise move it by the smallest possible amount to keep it within the theoretical bounds. We will see how this rule is derived from a dynamic programming problem in Section 11.

5 Reciprocity

Reciprocity has attracted considerable attention from anthropologists and ethnographers. In fact they typically recognize two types of economic transaction. Reciprocal exchange between two parties and redistributive exchange which is a centralised or collective exchange between households. These have been termed *centricity* and *symmetry* by Polanyi [59]. Redistributive exchange might be conducted through a Priest or Chief and examples would be communal storage or a tythe type system with redistribution to the needy. This distinction may be important and pursuing this distinction may be an important topic for future research. For the present I want to argue that collective exchange itself can be thought of as a system of reciprocal exchanges each with the Priest or Chief. A system or nexus of reciprocal exchanges can then be thought of as a solidarity network (see Fafchamps [23]). Thus I want to focus here only on reciprocal exchange.

Reciprocal exchange appears to be pervasive in rural communities. Sahlins [71] provides numerous examples ranging from studies of the Eskimo to studies of the !Kung to studies of Australian Aboriginals. History also offers many examples of reciprocity, for example in medieval villages (see e.g. [78]) and also in archaic periods. The greek didactic poet Hesiod who wrote around 700BC can be considered as the first economist.[7] One of Hesiod's poems is *Work and Days* where he writes about a collection on independent farming households. The poem can be considered as a series of aphorisms on how best to keep the household wealthy (see Millet [51]). One part of the poem deals with reciprocity

> Take fair measure from your neighbour and pay him back fairly with the same or better if you can; so that if you are in need afterwards, you may find him sure. (*lines 359-361*)

Sahlins [71] (developing the ideas of Malinowski [48]) identifies three types of reciprocal exchange, generalized, balanced and negative. Generalized and negative reciprocity are at two extremes with balanced reciprocity somewhere in the middle. Generalized reciprocity (also called weak or indefinite reciprocity) may take the form of a *"gift"* (see e.g. Malinowski [48] and Mauss [49]). This is not to say that the gift does not imply a counter obligation. Rather the reckoning of the debt cannot be overt and the recipient has only a vague obligation to reciprocate. The repayment may be in full or may be in part; it may come soon or it may never come. For example, if I invite you to dinner at

[7]The book by Barry Gordon [27] on economic analysis before Adam Smith begins with his writings

my house, I might think that at sometime I'll get an invitation from you; but if I don't it certainly won't stop me from inviting you again. The test of generalized reciprocity according to Sahlins is whether failure to reciprocate causes the giver to stop giving.

Balanced reciprocity is applied to transaction which involve a more complete reckoning of the counter obligation. There must be a tangible *quid pro quo*. It may be contemporaneous as in normal exchange transaction but it need not be. There will however be a firm expectation that a counter gift of approximately equal worth will be offered within some reasonable time period. The test of balanced reciprocity is the inability to tolerate one-way flows. The relationship between the parties will be disrupted if there is a failure to reciprocate.

At the other extreme is negative reciprocity (see Gouldner [28]). This is a situation where one party seeks to gain at the others expense. Theft comes into this category as would dishonestly supplying inferior goods etc.

Platteau [56] argues that most informal insurance arrangements are guided by principles of balanced reciprocity.[8] He cites the case of Senegalese small-scale fishermen who band together in order to provide a rescue service for fellow fishermen who get into difficulty at sea. They also commit to help repair or replace damaged or lost equipment. However, Platteau finds that these informal rescue organisations often break down as those who contribute but do not receive any benefit become frustrated with the arrangement.[9] Those who become so frustrated that they decide to leave ask for and get back the contributions the have previously paid. There is clearly an inability to tolerate one-way flows and therefore should be viewed as balanced rather than generalized reciprocity.

6 Why Reciprocate?

The key question is why reciprocate? The answer that I have suggested is that one makes a loan or a gift because the future benefits exceeds the current cost. That is one makes a loan in the anticipation of being a recipient in the future that is only if the promise to reciprocate is credible. I lend to to you because I anticipate the benefits exceed the cost and I know you will reciprocate at some points as you will have a similar calculation to

[8]Since generalised and negative reciprocity are at the two extremes most exchanges might be viewed as examples of balanced reciprocity

[9]Moral hazard or adverse selection does not seem to be a problem. Those rescued were not seen as being imprudent or bad fishermen, merely unlucky ones.

make. This idea can be found in Posner [62] and [63] and more explicitly in the work on self-enforcing agreements[10] by Telser [75]. It was applied to village economies by Kimball [38] and Fafchamps [23] who showed that it was possible for such a system to work and by Coate and Ravallion [15] who solved the static limited commitment problem.[11] Recently Kocherlakota [41] has characterized the long-run properties of the dynamic limited commitment solution in a symmetric environment. What we do is find the efficient solution to this problem in such a way that the theory can be empirically tested.

This is of course not the only possible reason to reciprocate and there are certainly other possible answers which have been suggested. It could be that the villagers are simple extremely moral and have a strong sense of social justice which involves raising the incomes of the poor. This is the view of Scott [72] who stresses that "the obligation of reciprocity is a moral principle *par excellence*. For Scott the village notion of social justice includes the right to a subsistence level of income and the village is seen as the institution which guarantees this subsistence income through a system of reciprocities. Popkin [60] and [61] has severely criticized Scott and what he calls the moral economists. He questions whether a peasant society is any more moral than any other society and cites evidence of selfish behaviour (see also Foster [26]). He asks how these norms of reciprocities are derived; how subsistence is defined and how needs are assessed. One telling criticism in my opinion concerns the "safety-first" principle also emphasized by the moral economists. The "safety-first" principle argues that villagers should and do avoid risk at all costs. Popkin points out that if villagers were so moral that they bailed-out anyone who fell below subsistence this would not be necessary.

Another possibility is that transfers are made for altruistic reasons. That is the gift contributes to the giver's utility. It is well recognized that many transfers are between family and friends — the F-connection as Ben-Porath [5] has called it. A number of authors have attempted to consider the role of altruism (see e.g. Ravallion and Dearden [67], Foster and Rosenzweig [25], Rosenzweig [68] and Stark [73]). I certainly do not want to dismiss altruism as a motive, the importance of family and friends in the informal market would not warrant it, but I suggest that it can't be a complete explanation. Altruism by itself cannot explain the use of loans rather than gifts, i.e. balanced rather than generalized reciprocity. It also predicts that a fall in the recipients pre-transfer income is met with an increase in the transfer received. Cox, Eser and Jimenez [18] use

[10] I first became interested in this problem when as an undergraduate I was required to read an article by Peter Hammond on trading Jam today versus Jam tomorrow [32].

[11] Another line of research has applied a similar approach to repeated prisoners' dilemma problems where there is no risk (see e.g. [65], [53]).

data from Peru and find a positive coefficient and conclude that a model where transfers are a response to incomplete capital markets is more appropriate.[12]

Other explanations have been offered in terms of *social exchange* or *tolerated theft*. The social exchange theorists (see e.g. Heath [35] for an exposition) hypothesize that the act of giving creates a counter exchange in terms of an intangible like respect or prestige or status or avoidance of guilt. Blurton-Jones [11] has also suggested the food-sharing is a form of tolerated theft: if the gifts were not given they would be stolen anyway. There may be some truth in both these notions but they can be criticised as giving no predictions about the size or nature of the gifts nor can they easily explain the use of loans instead of gifts.

Thus I find the interpretation of an informal insurance arrangement as a self-enforcing agreement quite a persuasive one. I happy to accept that moral principles, altruism and social exchange are part of the explanation. My opinion though, is that these are extras, something which is added on to explain behaviour. I should be happy to accept a parsimonious theory that could explain observed behaiour without them. It therefore seems like a useful exercise to see how well this theory on its own matches the data. I now turn to the data which we use to test the theory.

7 The ICRISAT data

The international crop research institute for the semi-arid tropics (ICRISAT) was founded 25 years ago in Hyderabad. It is part of the wider consultative group on international agricultural research (CGIAR). The semi-arid tropics are characterized by unpredictable weather with limited and erratic rainfall and nutrient poor soils. The semi-arid tropics extend over much of Africa and most of the Indian sub-continent. ICRISAT's basic mandate is to improve grain yield and farming technology and to identify and alleviate constraints on development in the semi-arid tropics through technological and institutional change.

It was in this context that ICRISAT undertook a detailed survey of three villages in India chosen in three different agroclimatic regions: Aurepalle in Mahbubnagar, Shirapur in Sholapur and Kanzara in Akola. The villages are rather different in nature. The populations of Aurepalle, Kanzara and Shirapur were 476, 169 and 297 households in

[12]There alternative is a Nash bargaining model between child and parent.

1975. Aurepalle has a very uncertain rainfall, and crops mainly sorghum during the rainy season. Shirapur suffers frequent crop failures and crops mainly sorghum after the rainy season. Kanzara has a much more assured rainfall and crops mainly cotton in the post-rainy season.

A selection of 40 households from each village were surveyed on a monthly basis for 10 years. Details were collected on crops planted and agricultural production; on household characteristics; on purchases and sales. In addition data on stock variables such as livestock, credit or debt levels was collected annually (for details see Walker and Ryan [82]). There are many advantages of this data. There is detailed data on a panel of households over a long period. The researchers lived alongside the villagers and were given incentives for accurate reporting as were the villagers for participation — there was an annual outing to a local temple or shrine. The study covers three different regions so that differences between the villages can be studied. The data set has become justifiably famous and has been used extensively by development economists.

There are also some disadvantages. There were some changes in survey technique during the study and there are doubts about the accuracy of reporting in the final three years. The landless labourers were generally underrepresented and showed the highest rate of attrition. The are however, two main drawbacks for our analysis. First, consumption was not directly measured but only calculated as a residual. This residual is calculated on the basis of transactions and end of year stocks so is only available on a yearly basis.[13] Thus we drop the first year of data because of concerns about the initial measurement of the stock variable and the last three years because of concerns about accuracy and use data on the 108 continuously sampled households over the period 1976–1981. Secondly, data was not collected on village wide aggregates. Since only a sample and not the entire village was surveyed we do not have an accurate measure of village wide income or consumption.

8 The extent of informal insurance

Suppose we accept that loans gifts and transfers are made because of an anticipation of credible reciprocation. Before we can test the theory we need to know what we have got to estimate, what are the important parameters that determine the extent of informal

[13]There is a belief that there was underreporting of consumption from own production and this could be correlated with actual production (see Ravallion and Chaudhuri [66]).

insurance and have some idea of their likely value. The extent of the informal insurance will depend on four things: the demand for insurance, the supply of insurance, the discount rate which measures how future income is treated relative to present income and the severity of any sanction in the case of a breach.

8.1 The demand for insurance

The demand for insurance depends upon risk and risk aversion. As I've said, risk is perhaps the most dominant factor of life in subsistence economies. In the ICRISAT data the coefficient of variation of income ranged from 10% to 80% with the majority falling in the 20% – 40% range. Thirty-two of the 108 households suffered one or more years where income was 50% or more below the median income. In the fishing villages of Poovar and Purakkad the coefficient of variation was even higher at over 100%.

The cost of the variation in income can be measured by the proportional risk premium. It measures the proportion of average income an individual would be prepared to give up to obtain a stable income level. It is given by the following simple formula:

$$\rho \approx \frac{1}{2} R v^2$$

where ρ is the proportional risk premium, R is the Arrow-Pratt coefficient of relative risk aversion and v is the coefficient of variation.

Thus to know the cost of the risk an estimate of the coefficient of risk aversion is needed. Binswanger [8] and [9] conducted a series of experiments to try to gauge risk aversion amongst the households in the ICRISAT survey. He offered a series of gambles were players were invited to choose one of the alternative gambles outlined in Table 3. This was done repeatedly and with four different amounts of money: the amounts in Table 3 were divided by a factor of 10 and multiplied by factors of 10 and 100. The first three of these games were played for real money; the game where gamble 1 was a sure gain of 500Rs was hypothetical. Someone who consistently chooses gamble 1 is extremely risk averse and is prepared to give up a large expected return for the safety of a certain gain. Someone who consistently chooses gambles 5 or 6 is risk neutral and always goes for the highest expected returns no matter what the risk. The modal choice was 3 or 4 indicating a moderate but not extreme risk aversion. It corresponds to a coefficient of relative risk aversion of around 2. This means that a farmer who faces a coefficient of variation of 0.4 and has a coefficient of relative risk aversion of 2, would be prepared to pay 16% of his wealth in order to stabilize his income.

Choice	Heads	Tails	Exp Value
1	5	5	5
2	9.5	4.5	7
3	12	4	8
4	16	2	9
5	19	1	10
6	20	0	10

Table 3: Binswanger's Experiment: The amounts are in Rs

Econometric evidence [2] also seems to support these results and evidence presented in Walker and Ryan [82] also finds that using the experimental results on risk aversion helped explain actual choices of savings and investment in irrigation. That is the more risk averse players adopted more cautious strategies for investment decisions.

8.2 The supply of insurance

As we have seen the is a farmer who faces a coefficient of variation of 0.4 and has a coefficient of relative risk aversion of 2 is prepared to pay 16% of his wealth in order to stabilize this income. The question is whether there is anyone in the village who would be prepared to buy this risk. There are two possibilities: risk-sharing and risk-pooling.

A risk shared is a risk halved. Consider the following simple example with two farmers both with a constant coefficient of relative risk aversion of 2. One has a risky income of either 60 or 140 with equal probability (this gives an expected value of 100 and a coefficient of variation of 0.4). The other has a sure income of 100. Farmer 1 is prepared to pay 16 to eliminate his risk. Suppose however the two farmers share their income 50:50 so each gets either 80 or 120 with equal probability. The coefficient of variation is 0.2 for each so each would be prepared to pay 4 to eliminate the risk. The total cost of the risk is now 8 rather than 16, so the cost of the risk has been halved. It is also clear that there is a potential trade here. Farmer 1 would be prepared to pay 12 to reduce the variation from 0.4 to 0.2 and farmer 2 is willing to accept 4 to take on the extra risk, i.e. increase his variation from 0 to 0.2. Thus a situation where farmer 2 accepts a premium of say 8 and agrees to share the risk 50:50 should be beneficial to both.

Of course they may be no one in the village who does not face risk so it is important to know if it is still possible to trade risk when all face risks. This is known as risk pooling. The extent to which this is possible depends on how covariate are the risks. For example if farmer 2 also has an uncertain yield of 60 and 140 but when farmer 1 had 60 farmer 2 has 140 then the two risks are perfectly negatively correlated and by sharing 50:50 they could perfectly stabilize their incomes. If on the other hand the risks were perfectly positively correlated, then no sharing can reduce the risks. An informal insurance arrangement can only work if incomes are not perfectly correlated. The degree to which risks can be reduced will depend on the covariance or correlation between the risks. Again this is something we teach our first year finance students. The price of a stock depends on its covariance with the market portfolio of stocks. If for example, the covariance is negative then one is prepared to pay a high price for the stock as it offers a hedge against existing risk.

The evidence suggest that the covariances are low. The covariances in the fishing villages of Poovar and Purakkad was very close to zero (see [56]). In the ICRISAT villages the correlations with average village income were on average around 0.2 but varied from -0.7 to 0.9 (see [79]). Thus there seems to be great scope for risk-pooling.

8.3 The discount rate

The rate at which villagers discount the future is important. If they completely discounted the future, then there would be no reason to make gifts or loans as the future reciprocation would not be valued.

John Pender conducted a series of experiments to find out the discount rate amongst villagers in Aurepalle. Like the experiments of Binswanger, these were real rather than hypothetical experiments. Respondents were asked to state their preference over a series of choices like those in Table 4. The rightmost column shows the implied discount rate if the respondent was indifferent between the two alternatives. Thus if a respondent picked September 1990 (now) in choices 1–4 but September 1991 in choices 5–8, then the discount rate would be in the range 20%–30%. Each respondent answered three similar sets of choices with different base amounts and then one choice was randomly assigned as a reward. Thus if the respondent chose September 1991 in choice 8 in Table 4 and this was the choice assigned to him, then he would receive 20 Kg of rice in September 1991. There were two key features of the results. The discount rates were highly variable and the average rate was extremely high compared to the results from similar experiments conducted in industrialized societies. The median discount rate was above 50% implying that most respondents would prefer to have 10 Kg now rather than 15 Kg in one years

Choice	September 1990	September 1991	Implied Discount Rate
1	10 Kg	9 Kg	-10%
2	10 Kg	10 Kg	0%
3	10 Kg	11 Kg	10%
4	10 Kg	12 Kg	20%
5	10 Kg	13 Kg	30%
6	10 Kg	15 Kg	50%
7	10 Kg	17 Kg	70%
8	10 Kg	20 Kg	100%

Table 4: Pender's Experiment

time.

It is important to note that these experiments are designed to find the intertemporal marginal rate of substitution. That is how one person values consumption now against consumption in the future. In fact we would like to know the rate of pure time preference: that is how one person values extra income now against extra income in the future with consumption the same in both periods. If however, average consumption is approximately constant and if marginal utility is a convex function of income, then Pender's estimates provide a lower bound for the pure rate of time preference. This implies an upper bound for the discount factor, which is one over one plus the discount rate of about two-thirds.

8.4 Sanctions

The most important sanction if one fails to reciprocate is the denial of future access to the informal market. Someone who defaults is viewed as untrustworthy and simply isn't trusted again. There is some evidence that this is what happens and that the fear of future loss of access is what motivates repayment.

The denial of future access to the informal market is an indirect cost but there may be direct costs as well. While there is no explicit legal enforcement it is probable that breaches of reciprocity lead to social stigma or other forms of social punishment. This might include ostracization or humiliation in front of the village elders. The evidence from the ICRISAT villages is that informal loans are almost never breached and that disputes between borrowers and village moneylenders are resolved by a village council. There is however, little direct evidence about what are the size of actual or perceived penalties.

9 Strategies for coping with risk

Insurance in the form of reciprocal gifts and loans is only one possible strategy for copying with risk. There are many other possibilities (see e.g. [17] or [79]). These may be usefully divided into income smoothing and consumption smoothing strategies (see [52]).

Income smoothing may be achieved by a variety of means. A classic example is the use of plot diversification using strip fields. McClosky [50] estimates that use of strip fields in medieval England cost about 10% of average income. Morduch [52] also cites evidence that households who face the most risk are more likely to plant lower yielding but hardier varieties. Farmers delay planting until there are more accurate weather forecasts and this can be costly in terms of average yields (see [10]). There is also evidence [69] that households most at risk are more likely to have a household member working in fixed wage employment either within the village or migrating and remitting part of the wages back to the household. Evidence of income smoothing is presented by Binswanger and Rosenzweig [7] who consider the effect of a one standard deviation increase in rainfall timing. As rainfall timing becomes riskier, it is to be expected that households will adopt more income smoothing measures which will reduce average profitability. They find that for a household with median wealth, profits are reduced by 15%. For a household in the bottom quartile, profits are reduced by 35%.

Likewise consumption smoothing can take many forms. We have identified gifts loans and transfer but there are other possibilities. One possibility is the use of storage to even out consumption. Grain can be stored from a good year to add to stocks in a bad year. Another possibility is the purchase and sale of other assets. Rosenzweig and Wolpin [70] find evidence that the purchase and sale of bullocks are used to stabilize consumption in the ICRISAT villages. Another possibility studied by Kochar [40] is the substitution of labour with householders working longer hours within and outside the smallholding. Jacoby and Skoufias [37] also show how smallholders withdraw their children from schooling in response to bad income shocks leading to underinvestment in human capital. Additionally marriage and migration have also been suggested as means of consumption smoothing, see [69] and [68].

To some extent all these methods are likely to be used. As we have said loans and transfers are best suited where risk is idiosyncratic and not highly covariate. Some strategies such as storage will be better at dealing with aggregate risk.[14]

[14] Storage in the form of bullocks will not work well in the case of aggregate risk as if everyone has a

10 Evidence

I have said that the non-market institutions in village economies are a partial and imperfect substitute for a complete set of contingent claims markets. To substantiate this claim it is necessary to show that the consumption allocations achieved by the non-market institutions and by all the various strategies to cope with risk do not in fact achieve the full insurance outcome.

In general the full insurance outcome can be derived as the solution to the following planner's problem

$$\max_{(c_i)_{i=1}^H} \sum_{i=1}^H w_i u_i(c_t^i) \qquad s.t. \qquad \sum_{i=1}^H c_t^i = Y_t$$

where w_i is the planner's or Pareto-weight given to household i and Y_t is the aggregate income at time t.[15] The first-order condition for the solution is

$$w_i u_i'(c_t^i) = \lambda_t \qquad \forall i.$$

These equations can be solved in simple cases. For example if all households have a constant relative risk aversion utility function with a coefficient of R, then

$$c_t^i = \left(\frac{w_i^{1/R}}{\sum_{i=1}^H w_i^{1/R}} \right) Y_t$$

or if all households have if all households have a constant absolute risk aversion parameter of A, then

$$c_t^i = \frac{Y_t}{H} + \frac{1}{A} \left(\log w_i - \frac{1}{H} \sum_{i=1}^H \log w_i \right).$$

Note that in each case full insurance implies equal shares when all the Pareto-weights are equal.

A number of authors have tested the implications of full insurance on the basis of these equations. Townsend [79] for rural India, Udry [81] for northern Nigeria, Grimand [30] for the Côte d'Ivorie, by Paxson [54] for Thailand and more generally by Deaton [19] and Deaton and Paxson [20]. All find that the presumption of full insurance is rejected. I don't find the rejection surprising, what is surprising is how well the non-market institution do in providing insurance in village economies. Townsend concludes

bad shock there will be no one to buy the bullock from you or the price will be depressed.

[15] To allow for possible savings aggregate income can be replaced by aggregate consumption and this is the procedure adopted in the empirical studies cited below.

that although full insurance is rejected it provides a pretty good benchmark. It is all the more surprising because evidence from the US e.g. [47], [16], [34] comes up with equivalent rejections. The weight of the evidence seems to suggest that the non-market institutions of less developed countries do almost as well at providing insurance as the market economies of developed nations.

Potentially the lack of full risk-pooling may be due to the limited commitment problem I have emphasized here, or because there are important asymmetries of information. It is likely that limited commitment is the greater problem in village economies which are cohesive economies where each knows the others business (for evidence see [46]). However, information problems should not be neglected and future work may build upon models of limited information (see e.g. Ligon [42] and Thomas and Worrall [77]).

11 Theory

This section shows how the optimum risk-pooling arrangement under limited commitment can be derived. It outlines the dynamic programming problem used to calculate the predicted consumption allocations under limited commitment. Section 12 outlines the computational procedure adopted to find the solution for the dynamic program. This procedure is then used with the income processes estimated from the ICRISAT data to generate predicted consumptions from the model which are compared with actual consumptions as explained in Section 13. Further details are given in Ligon, Thomas and Worrall [43].

Suppose there are H households, $i = 1, \ldots, H$. Each period $t = 1, 2, \ldots$, household i receives an income $y^i(s) > 0$ of a single perishable good, where s is the state of nature drawn from a finite set $s \in S$, and $S = \{1, 2, ..., S\}$. The state is a complete description of the income distribution at any particular date. It is assumed that the state of nature follows a Markov process with the probability of transition from state s to state r given by π_{sr}. This formalisation includes as a special case an identical and independent distribution over the possible states of nature (π_{sr} is independent of s). The general specification of the dependence of incomes $y_i(s)$ on the state of nature allows for arbitrary correlation between the two incomes. As we have seen in Section 8.2 incomes in agrarian communities are indeed covariate.

Household i has a per-period von-Neumann-Morgernstern utility of consumption function $u_i(c^i)$ which displays positive but diminishing marginal utility. Households are infinitely lived, discount the future with common discount factor δ, and are expected utility maximisers. We assume that the households enter into an implicit risk-sharing contract. While such a contract is not legally enforceable, there are two consequences for a party which reneges upon the contract. First, it loses future insurance possibilities. We assume that after a contract violation by any party, households consume at autarky levels thereafter. This can be interpreted as a breakdown of 'trust' between the households. Alternatively, viewing the contractual agreement as a non-cooperative equilibrium of a repeated game, since reversion to autarky is the most severe subgame-perfect punishment not only does a sustainable contract correspond to a subgame-perfect equilibrium, but also there can be no other equilibrium outcomes (see Abreu, [1]). Secondly, it is assumed that contract breaches meet some direct penalty. While there is no explicit legal enforcement, breaches probably lead to some social stigma or other social punishments as has been discussed above in Section 8.4. For simplicity we shall assume that a normalised expected discounted utility loss of $P^i(s) \geq 0$ is suffered by household i if it reneges in state s.

Let s_t be the state of the world occurring at date t. A contract will specify for every date t and for each history of states up to and including date t, $h_t = (s_1, s_2, ..., s_t)$, a consumption level $c^i(h_t)$. Define $U^i(h_t)$ to be the expected utility gain over autarky or *surplus* of household i from the contract from period t onwards, discounted to period t, if history $h_t = (h_{t-1}, s_t)$ occurs up to period t:

$$U^i(h_t) = (1-\delta)(u_i(c^i(h_t)) - u_i(y^i(s_t))) + E \sum_{j=t+1}^{\infty} (1-\delta)\delta^{j-t}(u_i(c^i(h_j)) - u_i(y^i(s_j))).$$

where E denotes expectation and per-period utility has been normalised by multiplying by $(1-\delta)$. The first term in above equation is the short run gain from the contract and the second term is the long-run or continuation gain from the contract. This equation can be definned recursively as

$$U^i(h_t) = (1-\delta)(u_i(c^i(h_t)) - u_i(y^i(s_t))) + \delta \sum_{r=1}^{S} \pi_{sr} U^i(h_t, r)$$

Household i will have no incentive to break the contract if the following *sustainability constraint* holds at each date t after every history h_t,

$$U^i(h_t) \geq -P^i(s_t),$$

If these equations hold $\forall i = 1, \ldots, H$, then we call the contract *sustainable*.

To solve for the (constrained) efficient set of sustainable contracts a relatively straightforward dynamic programming procedure can be followed. This relies on two key facts. First the Markov structure implies that the problem of designing an efficient contract is the same at any date at which the same state of nature occurs. Secondly, an efficient contract must, after any history, have an efficient continuation contract. The reason why all continuation contracts should be efficient is simply that all constraints are forward-looking and are (at least weakly) relaxed by moving to a Pareto dominating continuation contract that satisfies the sustainability conditions from an inefficient one, and such a move will make the overall contract Pareto-superior to the original one. This dynamic programming problem is similar in structure to that analysed by Thomas and Worrall [76].

For these reasons the Pareto frontier at any date t and given the current state s depends only on s and not on the past history which led to this state. This allows us to simplify and abuse notation slightly by letting U_r^i denote the continuation utility of household i when the state is r. Also let the Pareto frontier in state r be defined implicitly by the function $T_r(U_r^1, \ldots, U_r^H) = 0$. The arguments given in [76] and [43] show that the set defined by $T_r(U_r^1, \ldots, U_r^H) \leq 0$ is a convex set.

Let $\underline{U}_s^i$ denote the minimum sustainable surplus for household i in state s. By definition this cannot be below $-P^i(s)$, but it may not be possible to hold household i down to $-P^i(s)$ without consumption for household i becoming negative. Nevertheless $\underline{U}_s^i$ can be found when non-negativity constraints on consumption are imposed as the solution to the following equations

$$\underline{U}_s^i = \max\{(1-\delta)(u_i(0) - u_i(y^i(s))) + \delta \sum_{r=1}^{S} \pi_{sr} \underline{U}_r^i, -P^i(s)\} \quad \forall s \in S$$

It is easy to verify that the solution to these equations is unique and to see that if $P^i(s) = 0, \forall s \in S$ then $\underline{U}_s^i = 0$.

To find the Pareto-efficient contract, first consider the following maximisation problem.

$$\max_{(c_s^i)_{i=1}^H, ((U_r^i)_{r=1}^S)_{i=1}^H} \sum_{i=1}^{H} w_i \{(1-\delta)(u_i(c_s^i) - u_i(y_s^i)) + \delta \sum_{r=1}^{S} \pi_{sr} U_r^i\}$$

subject to

$$\begin{aligned} T_r(U_r^1, \ldots, U_r^H) &\leq 0 \qquad \forall r \in S \\ U_r^i &\geq \underline{U}_r^i, \qquad \forall r \in S \quad \forall i = 1, \ldots, H \end{aligned}$$

$$\begin{aligned}\sum_{i=1}^{H} c_s^i &= Y_s \\ c_s^i &\geq 0 \qquad \forall i = 1, \ldots, H\end{aligned}$$

where w_i is the Pareto-weight and $Y_s = \sum_{i=1}^{H} y_s^i$ is aggregate income in state s. Following [33] this problem can be decomposed into a number of sub-problems. The first sub-problem is that outlined in the Section 10

$$\max_{(c^i)_{i=1}^{H}} \sum_{i=1}^{H} w_i u_i(c_s^i) \qquad s.t. \qquad \sum_{i=1}^{H} c_s^i = Y_s \qquad \text{and} \qquad c_s^i \geq 0 \quad \forall i = 1, \ldots, H.$$

The first-order conditions are for any pair of households i and k

$$\frac{u_i'(c_s^i)}{u_k'(c_s^k)} = \frac{w_k}{w_i} + \frac{\psi^k - \psi^i}{w_i u_k'(c_s^k)}$$

where ψ^i is the multiplier on the non-negativity constraint for household i consumption. We can write the solution as $c^i(w, Y_s)$ where $w = (w_1, \ldots, w_H)$ is the vector of Pareto-weights and the indirect utility function as $v_i(w, Y_s) = u_i(c^i(w, Y_s))$.

There are also S sub-problems of the form

$$\max_{(U_r^i)_{i=1}^{H}} \sum_{i=1}^{H} w_i U_r^i \quad s.t. \quad T_r(U_r^1, \ldots, U_r^H) \leq 0 \quad \text{and} \quad U_r^i \geq \underline{U}_r^i \quad i = 1, \ldots, H.$$

The first-order conditions give for any pair of households i and k

$$\frac{w_k + \phi_r^k}{w_i + \phi_r^i} = \frac{\partial T_r / \partial U_r^k}{\partial T_r / \partial U_r^i}$$

where ϕ_r^i is the multiplier on the sustainability constraint for household i. It is clear as argued above that the solution involes $T_r(U_r^1, \ldots, U_r^H) = 0$, so that the continuation contract is (constrained) Pareto-efficient. Consider then the Pareto problem without the sustainability constraints where the weights are denoted $\tilde{w}$ to distinguish it from the former problem.

$$\max_{(U_r^i)_{i=1}^{H}} \sum_{i=1}^{H} \tilde{w}_i U_r^i \quad s.t. \quad T_r(U_r^1, \ldots, U_r^H) \leq 0.$$

The first-order conditions give

$$\frac{\tilde{w}_k}{\tilde{w}_i} = \frac{\partial T_r / \partial U_r^k}{\partial T_r / \partial U_r^i}$$

Denote the solution $V^i(\tilde{w}, r) = U_r^i(\tilde{w})$ for each household i, as the conditional household value function (conditional on the state). These value functions map Pareto-weights to continuation utilities in a Pareto-efficient way. They obey the simple recursive relationship

$$V^i(w, s) = (1 - \delta)(v_i(w, Y_s) - u_i(y_s^i)) + \delta \sum_{s=1}^{S} \pi_{sr} V^i(\tilde{w}, r)$$

Then the S sub-problems can be replaced by

$$\max_{(\tilde{w}_i)_{i=1}^H} \sum_{i=1}^H w_i V^i(\tilde{w}, r) \quad s.t. \quad V^i(\tilde{w}, r) \geq \underline{U}_r^i \quad \forall i = 1, \ldots, H.$$

where the value functions are used so that the next period Pareto-weights $\tilde{w}$ become the maximand instead of the continuation utilities. It is clear from differentiating the first-order conditions for this problem that

$$\sum_{i=1}^H \tilde{w}_i \frac{\partial V^i(\tilde{w}, r)}{\partial \tilde{w}_k} = 0 \qquad \forall k = 1, \ldots, H.$$

so that in the absence of the sustainability constraint, the solution is $\tilde{w} = w$ and the Pareto-weights change only in response to binding sustanability constraints.

The relationship between $\tilde{w}$ and w when there are binding sustainability constraints can be described by combining the first-order conditions for the two problems defined above

$$\frac{\tilde{w}_k}{\tilde{w}_i} = \frac{w_k/w_i + \phi_r^k/w_i}{1 + \phi_r^i/w_i}$$

This gives an updating rule for the ratio of the Pareto-weights. Thus given an initial set of weights the contract can be computed recursively by updating the weights as determined by the actual state and the equation given above.

This equation is most easy to interpret when the non-negativity constraints on consumption do not bind. In that case the ratio of the Pareto-weights, w_k/w_i is simply equal to the ratio of the marginal utilities

$$RMU_s^{i,k}(t) = \frac{u_i'(c_s^i)}{u_k'(c_s^k)} = \frac{w_k}{w_i}.$$

Then the updating rule for the ratio of the marginal utilities is

$$RMU_r^{i,k}(t+1) = \frac{RMU_s^{i,k}(t) + \phi_r^k(t+1)/w_i(t)}{1 + \phi_r^i(t+1)/w_i(t)}$$

To understand this rule suppose for example, that $\phi_r^i(t+1) > 0$ and $\phi_r^k(t+1) = 0$ so that household i has a binding sustainability constraint in state r at date $t+1$ but that household k is unconstrained. The updating rule shows that $RMU_r^{i,k}(t+1) < RMU_r^{i,k}(t)$. Writing the marginal rate of substitution between t and $t+1$ as

$$MRS_{t,t+1}^i = \frac{\delta u_i'(c_r^i(t+1))}{u_i'(c_s^k(t))}$$

it follows that $MRS^i_{t,t+1} < MRS^k_{t,t+1}$. Thus given period t consumption, it would be beneficial at date $t+1$ to equate the marginal rates of substitution for households i and k by raising $c^k_r(t+1)$ and reducing $c^i_r(t+1)$. It is however, not desirable to reduce $c^i_r(t+1)$ since future consumption would have to be raised to maintain the expected discounted utility of household i and not violate its sustainability constraint and this would lead to a worse pattern of consumption from the point of view of risk-pooling.

12 Computational approach

To solve the above problem it is necessary to determine the conditional value functions $V^i(w,r)$. These can be calculated using an iterative procedure starting with the first-best value functions (where the sustainability constraints are ignored). I will outline this procedure for the case of two households where the states are identically and independently distributed over time $\pi_{sr} = \pi_r$. It is computationally simpler to work with the unconditional value functions

$$W^i(w) = \sum_{r=1}^{S} \pi_r V^i(w,r)$$

In the $i.i.d$ case there are just two unconditional value functions, one for each household.[16] The Pareto-weights can be normalised so $\sum_{i=1}^{H} w_i = 1$, so with two households it is only necessary to calculate one weight. To distinguish this case, let θ be the Pareto-weight for household 1 and let $1-\theta$ be the Pareto-weight for household 2.

There is then a simple procedure for calculating the two unconditional value functions, $W^i(\theta)$. First calculate the indirect utility functions $v_i(\theta, Y_s)$ and compute an initial unconditional first-best value function as follows

$$W^i_0(\theta) = \sum_{s=1}^{S} \pi_s (v_i(\theta, Y_s) - u_i(y^i_s))$$

Next compute $\underline{U}^i_s$ and solve the $2S$ equations

$$(1-\delta)(v_i(\theta, Y_s) - u_i(y^i_s)) + \delta W^i_0(\theta) = \underline{U}^i_s$$

for θ. This gives S intervals $[\underline{\theta}_s, \bar{\theta}_s]$ where $\underline{\theta}_s$ is computed from the equations for household 1 and $\bar{\theta}_s$ is computed from the equations for household 2. These intervals correspond to the theoretical bounds drawn in the figures in section 4. New values of θ say $\tilde{\theta}$ can be

[16] In general there are HS value functions to compute.

computed by the rule that θ is kept constant if it falls within the interval or moves to the nearest endpoint if it does not.[17] This gives $\tilde{\theta}$ as a function of θ in state s, say $\tilde{\theta}_s(\theta)$. Two new value functions can then be computed according to

$$W_1^i(\theta) = \sum_{s=1}^{S} \pi_s((1-\delta)(v_i(\tilde{\theta}_s(\theta), Y_s) - u_i(y_s^i)) + \delta W_0^i(\tilde{\theta}_s(\theta)))$$

and the process repeated until the difference between the value functions $W_{j+1}^i(\theta)$ and $W_j^i(\theta)$ or the difference between the interval endpoints $[\underline{\theta}_s, \bar{\theta}_s]$ at successive iterations is arbitrarily small.[18] This computation procedure and the simulation of predicted consumptions can be implemented with a Mathematica package.[19]

13 Empirical analysis

To test the limited commitment model against the alternatives we [43] use data from the ICRISAT villages. The first and last three years of the sample are dropped because of concerns about accuracy of the data and only households continuously in the sample are used. Consumption and income are measured at a household level and following [79] converted into adult equivalents.

There are perhaps a number of ways in which the model may be tested. One implication of the model is the prediction that good and bad shocks will be asymmetrically insured. That is suppose someone in the village has a bad shock, then it may be that all other villagers will find it in their interest to make a small contribution. On the other hand someone who gets a particularly good income will be reticent to share this with everyone else, he will have to make a large contribution now and this may not be in his interest. Such households with high income growth are more likely then to experience higher variance of consumption. We have tried to test this using and F-test for differences between the variances between households with high and low income growth. The results are generally supportive. However, we decided not to adopt this approach because the identification of high income growth households as being constrained may not hold for

[17] For a proof see [76].

[18] It can be shown that starting with the first-best value functions as described above, convergence is assured.

[19] The package is available upon request. The package solves the two identical household problem with constant relative risk aversion. It computes the solution to the full-insurance, static limited commitment and dynamic limited commitment problems and simulates predicted consumptions for each model along with the ad hoc alternative.

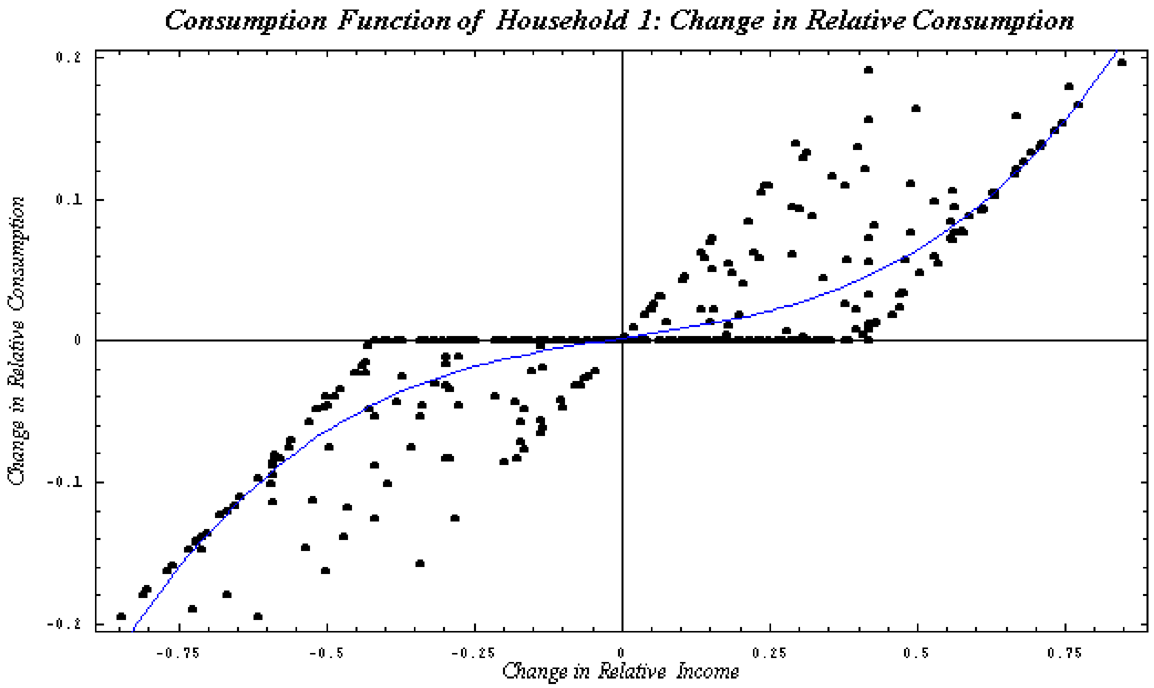

Figure 3: Consumption Plot — Dynamic Limited Commitment

if income is negatively serially correlated, then a high income may be followed by a low income and you might be keen to give up your income now in return for income next year. In other works it is only a test of a more restricted theory. Another possibility is simply to look at consumption against income. To see what the implication might be, consider the plot of the change in relative consumption against the change in relative income in Figure 3 which is derived from the simulation exercise outlined in Section 4. What we can see from this is that some positive and negative changes are insured against and involve no change in relative consumption but some are not. We can contrast with two alternatives. Full insurance where relative consumption is kept constant and an ad hoc model. The ad hoc model is where each household gives a proportion, say k, of its income to the village, and the total given is redistributed equally to all households. Thus the consumption of a houshehold is

$$c_t^i = (1-k)y_t^i + \frac{1}{H}kY_t$$

Thus with this ad hoc rule, the change in relative consumption is proportional to the change in relative income.

$$\left(\frac{c_{t+1}^i}{Y_{t+1}} - \frac{c_t^i}{Y_t}\right) = (1-k)\left(\frac{y_{t+1}^i}{Y_{t+1}} - \frac{y_t^i}{Y_t}\right)$$

as is illustrated in Figure 4. This suggests that fitting a cubic equation to the data and finding a significant coefficient on the cubic term may provide some evidence in favour of

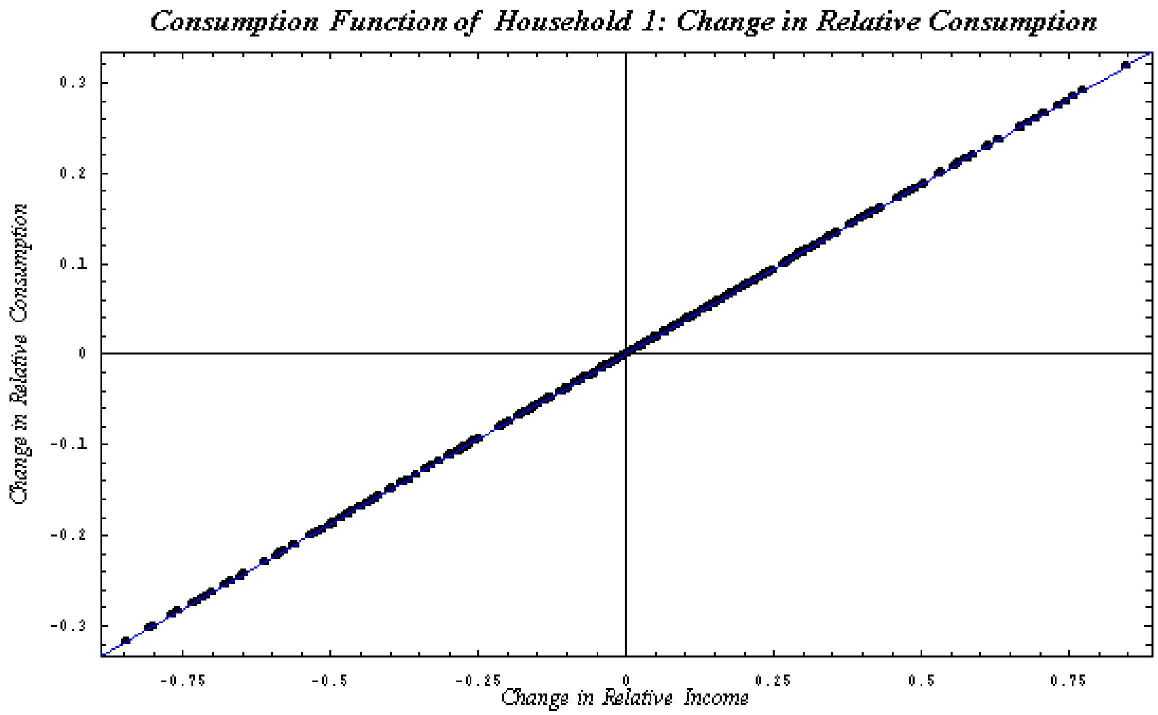

Figure 4: Consumption Plot — Ad Hoc Model

the limited commitment model over the full insurance or ad hoc models. One problem with this is that the pattern of relative income and consumption changes under static limited commitment looks very similar (see Figure 5) and it may be difficult to distinguish between the two limited commitment models on this criterion.

We therefore adopt an alternative procedure which is as follows. We assume that preferences are of the form

$$u(c) = \frac{c^{1-\gamma} - 1}{(1-\gamma)}$$

so have constant relative risk aversion parameter γ. We the estimate a household specific income process and use a finite cell approximation for each household and for the rest of the village. We then compute the optimum contractual arrangement between each household and the rest of the village for some given parameter values of the discount factor δ, the coefficient of relative risk aversion γ and the direct penalty. We then use data on first period actual consumption to generate an initial vector of consumption shares. Next we use actual incomes to generate the predicted consumptions from the model. Finally we repeat the process for different parameter values and choose the parameters to minimise the sum of the squared residual errors between the actual and the predicted consumptions.

We do this for the each of the three villages and for the alternative models of full-

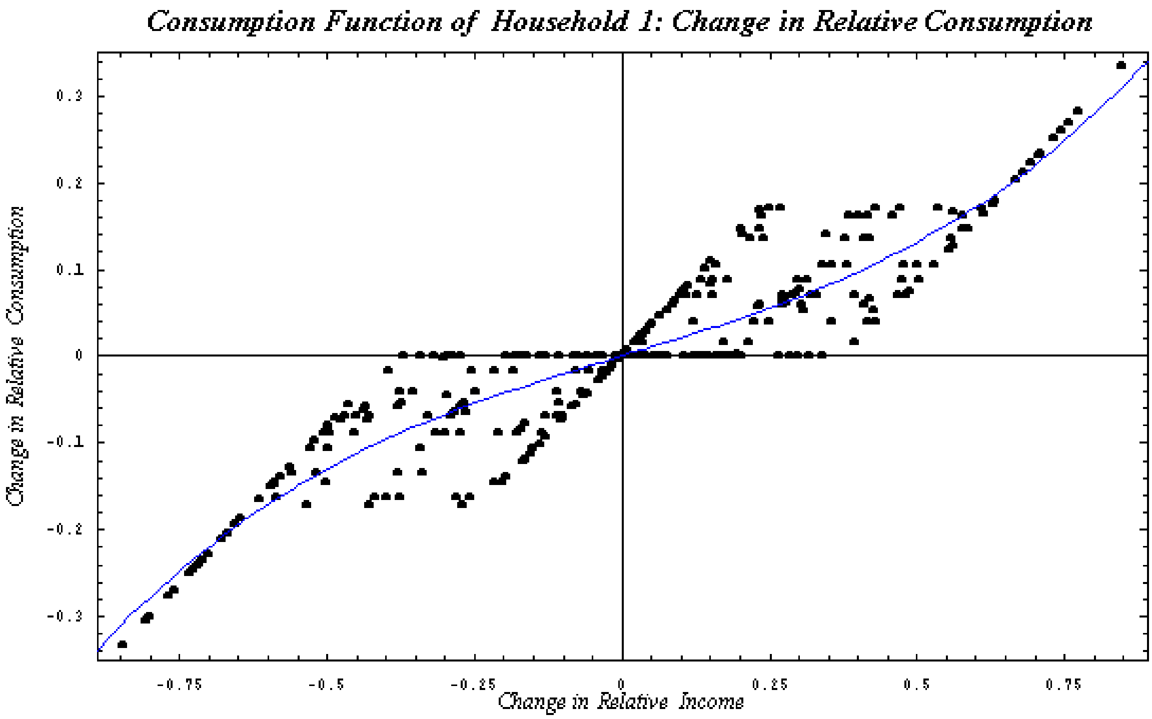

Figure 5: Consumption Plot — Static Limited Commitment

insurance, static limited commitment and dynamic limited commitment. The results are given in Table 5.

A simple test of our procedures is to see if the parameter estimates are reasonable. The estimates of the coefficient of relative risk aversion varies from 1.3 to 2.4 so is within the range calculated by Binswanger [8]. The estimates for the discount factor are also in the range predicted by Pender [55] of 0.5 to 0.7 for Shirapur and Kanzara but the estimate of 0.04 for Aurepalle is unreasonable. The penalty estimates are computed as a ratio to the average net gain from the contractual arrangements within the village. They are small in absolute value but appear large as a proportion of the average surplus. Thus the parameter estimates are mostly reasonable and give some indication that the estimation procedure is satisfactory. The Log likelihood ratios can be used to show that the dynamic limited commitment model out performs both static limited commitment and full insurance in all villages.[20]

Although the limited commitment model performs well it actually predicts more insurance than is actually observed as is shown in Table 6. This shows the results of regressing actual consumption on actual income, aggregate consumption and the consumption

[20] A χ^2 test was performed on the likelihood ratios producing a significant result in all cases.

Village	**Model**	**Risk**	**Penalty**	**Discount**	**Log likelihood**
	Full	1.7415	–	–	-1293.8627
Aurepalle	StaticLC	1.6418	0.8231	–	-1284.0782
	DynamicLC	1.3390	0.8667	0.0433	-1279.6161
	Full	1.8881	–	–	-1391.3818
Shirapur	StaticLC	2.1906	0.9556	–	-1382.5174
	DynamicLC	2.2916	0.9233	0.5036	-1380.0622
	Full	1.9009	–	–	-1384.8700
Kanzara	StaticLC	2.2198	0.9511	–	-1379.1900
	DynamicLC	2.3194	0.7926	0.6945	-1365.6128

Table 5: Estimates of Model Parameters

Village	**Income**	**Agg. Cons.**	**LC Cons.**
Aurepalle	0.0926*	0.2427	0.6627*
	(0.0198)	(0.1917)	(0.1668)
Shirapur	0.0976*	-0.6118	1.5905
	(0.0241)	(0.9928)	(0.9385)
Kanzara	0.1199*	0.2214	0.7655*
	(0.0211)	(0.3527)	(0.3290)
All	0.1020*	0.0850	0.8583*
	(0.0126)	(0.1371)	(0.0775)

Table 6: Consumption Regressions.

predicted by the limited commitment model.

To interpret Table 6 recall that full insurance predicts that individual consumption should depend only on aggregate consumption. The ad hoc rule is a linear combination of aggregate consumption and individual so if the ad hoc model were correct the coefficients on both individual income and aggregate consumption should be significant but the coefficient on the limited commitment consumption should be zero. It is clear that neither the full insurance nor the ad hoc model are supported by these results. The limited commitment consumption is significant in Aurepalle and Kanzara and large but insignificant in Shirapur. The individual income coefficient is however always significant, indicating that household income still helps to explain household consumption.

14 Conclusions and future research

The use of data from village economies provides a very useful test of recent theories from contract theory and mechanism design. We have looked at one particular theory, namely the theory of self-enforcing agreements. This is a new and important topic area. The only other tests of this theory that we are of, are [25], [46] both on village economies and [4] on labour data.

This is also important from a policy perspective we need to have a good theory of informal credit or insurance arrangements if new policy aimed an improving productivity through new credit institutions is going to work.

We find that the theory performs reasonably well and out performs the alternatives of full-insurance, static limited commitment and the ad hoc partial insurance model. It does not perform perfectly and in particular predicts too much insurance. I conclude that there is still much scope for future research.

One important point left out of the analysis above is storage. This is an important because the ICRISAT villages exhibit high levels of storage. Ongoing work [44] examines the dynamic limited commitment model when households can engage in self-insurance by storage. The introduction of storage has three effects. First, when the aggregate income is uncertain, individual savings help to smooth aggregate consumption. Secondly, a household with large savings may find autarky relatively attractive and be less inclined to grant loans. Thirdly, assets can be transferred across households to improve welfare. What emerges is a theory of a dynamic distribution in which shifts in the ownership of storable assets help to support an equilibrium.

Another deficiency of the model is that it explains actual consumption patterns but not the pattern of transfers. There may be many different transfer patterns that lead to the same allocation. Remember that households are often on both sides of the market at the same time. One possibility is that altruism in addition to limited commitment might give predictions about transfers. Another possibility is that maintaining links with potential partners is costly, so that it is best to maintain relatively few links. Both these are foreseen as future work.[21]

A further possible explanation for the result that there is too little insurance is that

[21] The sociologist, Mark Granovetter [29] advocates embedding the assumption of rational maximizing agents within a social or network structure and this approach can be seen to be in thtat tradition.

there are other important constraints that we have not taken into account. The obvious one is informational problems. For example a household may have less of an incentive to work hard on the farm if it is known that the informal insurance arrangement will bail it out. Taking these factors into account should improve the predictive content of the theory.

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