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Reciprocity without commitment

Characterization and performance of informal insurance arrangements*

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Various risk sharing arrangements are common in underdeveloped agrarian economies where households have no formal means of contract enforcement and little access to risk markets. Social insurance is still possible through repeated interaction in an environment with few informational asymmetries. In a simple repeated game model of two self-interested households facing independent income streams, we characterize the best arrangement that can be sustained as a noncooperative equilibrium. We establish precisely how this optimal informal arrangement differs from first best-risk sharing, and identify the conditions under which the divergence between the two is greatest.

1. Introduction

Modern insurance arrangements take the form of written and legally binding contracts which stipulate transfer payments contingent on certain events occurring. These arrangements require a government to record and enforce written contracts and a literate population to make such contracts. Thus insurance markets are not found in primitive societies. Nor is insurance based on explicit contracts common in many present day developing countries; illiteracy, cultural intimidation by modern institutions, and

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problems of asymmetric information can effectively restrict access by the poor even when a formal insurance market does exist.

When explicit and binding contracts are not possible, risk-sharing arrangements will have to be sustainable on an informal basis. This clearly makes them more difficult to implement; if there is only one realization of the risky event, no self-interested person would have an incentive to share realized good fortune, and so will renege on any prior non-binding agreement. However, as first shown by Kimball (1988) and also by Foster (1988),[1] risk sharing among non-altruists may exist in replications of a suitably risky environment without the advantage of binding contracts; current generosity may then be justified by expected future reciprocity. This may not be an unreasonable expectation in a traditional village society, where generations of households remain in relatively close contact, and the need to spread risk is often great.

Indeed, there is considerable evidence of the existence of various forms of informal insurance arrangements in village communities,[2] though they have received rather little attention from economists.[3] Scott (1976) and others have described and discussed at length village level customs of mutual support in traditional societies – the so-called 'moral economy'. The forms of such behavior which have been observed include gift giving, reciprocal interest free credit, shared meals, communal access to land, sharing bullocks, and work-sharing arrangements. The main risks covered are accidents or illnesses of productive family members or livestock, certain forms of crop damage, such as due to fire or wild animals, and other relatively non-covariate income fluctuations, such as fishing yields. A recurrent feature of these practices is their reciprocity: recipients at one date often become donors at another.

The performance of these informal insurance arrangements has been an issue in the anthropological literature. Popkin (1979) is staunchly critical of the 'moral economists' (more of whom were anthropologists than economists) for over-stating the value of indigenous institutions. However, while it is not unusual to find a seemingly romanticized view of these institutions in the literature, it is at least as common to find sobering reservations. For

[1]Kimball develops his analysis to assess the scope for farmers' cooperatives as risk-sharing institutions in medieval England. Foster, on the other hand, is concerned with family based risk-sharing arrangements in developing countries.

[2]On informal insurance in traditional village societies see Scott (1976), Dirks (1980), Posner (1980), Watts (1983), Caldwell et al. (1986), Platteau and Abraham (1987), Platteau (1988), Ravallion and Dearden (1988), Rosenzweig (1988), Thomas et al. (1989), Townsend (1991), and Ravallion and Chaudhuri (1991). Note that these institutions are not confined to traditional village societies. See, for example the empirical results of Kaufman and Lindauer (1984) (for urban El Salvador), and Ravallion and Dearden's (1988) results (for both urban and rural Java). Transfers between traditional and modern sectors also appear to be common.

[3]For example, Newbery's (1989) recent survey, 'Agricultural Institutions for Insurance and Stabilization', makes only a brief mention of informal insurance.

example, Scott (1976, p. 43) writes that: 'village redistribution worked unevenly and, even at its best, produced no egalitarian utopia'. There is also some evidence to suggest that, even when they do exist, traditional risk-sharing arrangements may well break down, and at particularly bad times for the poor. A number of observers have noticed the collapse of community based insurance during famines; for example, a common Bengali word for describing famine is 'durbhiksha' literally meaning that 'alms are scarce'.[4]

The performance of these institutions also has bearing on longstanding policy concerns. In the absence of informal insurance, incomplete risk markets yield a strong prima facie case for policy intervention [Newbery and Stiglitz (1981)]. With the existence of informal insurance possibilities that case is less clear. This can be viewed as an example of a more general point: while there is a case for intervention in one shot games of the Prisoners' Dilemma sort, that case may be significantly weakened if the game is repeated.[5] Indeed, it may even be argued that, without any policy intervention, private voluntary arrangements within the village community will adequately supply insurance against idiosyncratic income shocks.

In this paper we build on the work of Kimball and Foster to further develop a theoretical understanding of the risk-sharing that can be achieved with informal insurance arrangements. We characterize the 'best' informal insurance arrangement which can be sustained as a noncooperative equilibrium and compare its properties with those of the arrangement which could, in principle, be achieved with binding contracts. We show precisely how the two differ and try to identify the circumstances under which the divergence between them is likely to be the greatest.

While we use the same basic model as Kimball and Foster, our analysis differs from theirs in focusing on the properties of the optimal informal insurance arrangement and how it differs from the first-best. In Foster's analysis households' actions are restricted to one of two extremes: to pool income fully, or to defect. As we show later, the optimal arrangement will typically involve an intermediate strategy in which, while transfers are made, full income pooling is not achieved. While Kimball does allow for the possibility of less than full income pooling, he limits his analysis to identifying the conditions under which transfers of some form will take place (i.e., a risk-sharing institution will exist) and under which full income pooling will be achieved (i.e., the institution will achieve first-best risk sharing). Thus Kimball is not concerned with the properties of the optimal equilibrium insurance arrangement.

The next section outlines our repeated game model and characterizes those

[4]Declines in patronage and customs of gift giving during famines have been noted by Epstein (1967), Sen (1981), Currey (1981), Greenough (1982), Ravallion (1987), D'Souza (1988), and Drèze and Sen (1989).

[5]Sugden (1986), for example, has argued along these lines.

insurance arrangements which are sustainable as subgame perfect equilibria. Section 3 then characterizes the 'best' of these implementable arrangements and compares it with first-best risk sharing. Section 4 examines comparative static properties of the optimal insurance arrangement. Section 5 presents parameterized numerical simulations of the optimal arrangement and examines how its performance relative to the first-best varies with the parameter values. Section 6 offers some suggestions for further research, while our conclusions are summarized in section 7.

2. A simple informal insurance game

2.1. The basic model

We use the same basic model studied by Kimball (1988). This provides an adequate yet tractable characterization of the sort of environment in which informal insurance may exist. We consider two risk-averse households who face intertemporally variable and independent income streams, so they may have different incomes at any given date. The two households are similar ex ante, having the same preferences and the same expected income.

In each period, each household $k=\text{A},\text{B}$ receives an income y^k drawn from the set $\{y_1,\dots,y_n\}$ in which incomes are ranked in ascending order, $y_1<\cdots<y_n$. The probability that household A receives an income y_i and B an income y_j is denoted π_{ij}; i.e. $\pi_{ij}=\text{Prob}\{(y^{\text{A}},y^{\text{B}})=(y_i,y_j)\}$. We confine attention to symmetric probabilities whereby, for all i, $j\in\{1,\dots,n\}$, $\pi_{ij}=\pi_{ji}>0$. Thus, each income pair is possible and the probability that A gets y_i and B gets y_j equals the probability that A gets y_j and B gets y_i.[6] The players have identical preferences defined over own income only and represented by the (per period) utility function $u(y)$. We assume that they are non-satiated and risk averse, i.e., for all $y>0$, $u'(y)>0$ and $u''(y)<0$. In addition, each household has a utility discount rate or 'subjective rate of time preference' r. As we wish to focus attention on income transfers as a means of insurance, we shall assume that households do not save.

Since both households are risk averse and face uncertain income streams, there are potential gains from state-contingent transfers between them; A agrees to help B out if B is unlucky and, in return, B agrees to help A out when their situations are reversed. In the absence of binding contracts, such arrangements cannot be sustained in one period interactions. No matter what is agreed ex-ante, the household who obtains the highest income will always renege. In repeated interactions, however, such transfer arrangements can be sustained.

[6]This can be interpreted as 'ex-ante-equality'; either player could end up 'rich' or 'poor' in any period.

To make this precise we consider the following repeated noncooperative game. In each period t, nature selects an income pair $y(t)=(y^A(t), y^B(t))$. Observing $y(t)$ and knowing the history of the game, each household must choose a transfer to the other household. The game is assumed to be infinitely repeated,[7] and the equilibrium concept we shall employ is the usual one of subgame perfect equilibrium.[8]

Since each individual's life-span is of finite duration our assumption that the game is infinitely repeated needs justification. The idea we have in mind is that, in a traditional village setting, households are likely to be in contact with each other for more than one generation. Thus the current head of the household may decide to help out other households in the expectation that they in turn will be around to help out his/her offspring should they need it. The players can thus be interpreted as dynasties. It may be too strong to postulate that households expect with certainty to be playing the game for the rest of time, but that is more than we need. All that is necessary, is that households believe that there is a positive probability that the game will continue to be played. This probability assessment can be thought of as being reflected in agent's discount rates. The less likely they think that future generations will be playing the game, the higher the discount rate.

2.2. *Informal insurance arrangements*

Our first objective is to characterize the insurance arrangements which can be implemented by the equilibria of this game. An arrangement specifies a net transfer between the two players for each realized income pair. We follow Foster and Kimball in restricting attention to pure insurance arrangements, whereby the transfers at any date depend only on incomes realized at that date. This precludes possible credit features of informal risk-sharing arrangements whereby transfers are more like loans which are paid back at least in part at some later date. We briefly comment on the effects of allowing these in section 6.

Formally then, we define an *informal insurance arrangement* to be an $n \times n$ matrix $\Theta=(\theta_{ij})$ where the component θ_{ij} denotes the net transfer from A to B when A gets an income y_i and B gets y_j. Feasibility demands that

[7]If the game were of finite duration and the termination date were common knowledge the usual backward induction argument would suggest that the only equilibrium would be zero transfers. If the termination date were uncertain, as seems reasonable in this context, then transfers may still be possible. See Basu (1987) for a discussion of finitely repeated games with uncertain termination.

[8]To save notation, we will not define precisely what is meant by a subgame perfect equilibrium. For a definition of this concept, see Friedman (1986). For a general characterization of subgame perfect equilibria in infinitely repeated games with discounting see Abreu (1988).

$\theta_{ij} \in [-y_j, y_i]$. Under the arrangement Θ, A' : period expected utility will be

$$v^A(\Theta) = \sum_{i=1}^{n} \sum_{j=1}^{n} \pi_{ij} u(y_i - \theta_{ij}),$$

and B's expected utility is

$$v^B(\Theta) = \sum_{i=1}^{n} \sum_{j=1}^{n} \pi_{ij} u(y_j + \theta_{ij}).$$

Let $\bar{v}$ denote each household's per period expected utility in the absence of any kind of informal insurance, i.e.,

$$\bar{v} = \sum_{i=1}^{n} \sum_{j=1}^{n} \pi_{ij} u(y_i) = \sum_{i=1}^{n} \sum_{j=1}^{n} \pi_{ij} u(y_j).$$

An arrangement is *implementable* if there exist equilibrium strategies for the players which result in net transfers consistent with it. An arrangement will be implementable if the difference between each household's expected utility under continued participation and the status quo (i.e., zero transfers) is always greater than the gain from current defection. Strategies which follow the arrangement until defection and then punish defections by setting all future transfers equal to zero will implement any such contract. Conversely, since the status quo is the worst possible equilibrium, any implementable arrangement must necessarily satisfy the condition that the difference between each household's expected utility under continued participation and the status quo is always greater than the gain from current defection. Thus an arrangement is implementable if and only if[9]

$$u(y_i) - u(y_i - \theta_{ij}) \leqq (v^A(\Theta) - \bar{v})/r \quad \text{for} \quad \text{all } (i, j) \tag{1}$$

and

$$u(y_j) - u(y_j + \theta_{ij}) \leqq (v^B(\Theta) - \bar{v})/r \quad \text{for} \quad \text{all } (i, j). \tag{2}$$

We refer to these as the *implementability constraints.*[10]

An arrangement is *symmetric* if the net transfer from A to B when

[9]For a formal proof of this assertion see the earlier version of this paper [Coate and Ravallion (1989)].

[10]These implementability constraints are similar to those which arise in the labor economics literature on 'self-enforcing' wage contracts. See Thomas and Worrall (1988).

$(y^A, y^B) = (y_i, y_j)$ equals the net transfer from B to A when $(y^A, y^B) = (y_j, y_i)$ i.e., if $\theta_{ij} = -\theta_{ji}$.[11] Clearly, if Θ is symmetric then $\theta_{ii} = 0$ for all i. It follows that a symmetric arrangement is completely characterized by the vector

$$\theta = (\theta_{21}; \theta_{31}, \theta_{32}; \ldots; \theta_{n1}, \ldots, \theta_{nn-1}).$$

Thus, if we know the net transfer from A to B for each case where A has a strictly larger income than B, then we know the entire transfer arrangement. Each household's utility can be rewritten in terms of the vector θ. Let

$$v(\theta) = \sum_{i=1}^{n} \left[\sum_{j=1}^{i-1} \pi_{ij}(u(y_i - \theta_{ij}) + u(y_j + \theta_{ij})) + \pi_{ii} u(y_i) \right].$$

Then it is straightforward to verify that $v^A(\Theta) = v^B(\Theta) = v(\theta)$. This observation allows us to simplify the implementability constraints. In particular, it is easily verified that a symmetric, non-negative arrangement θ is implementable if and only if for all $i = 1, \ldots, n$,

$$u(y_i) - u(y_i - \theta_{ij}) \leq [v(\theta) - \bar{v}]/r, \quad j = 1, \ldots, i-1. \tag{3}$$

By a non-negative arrangement we simply mean one with the property that the net transfer from A to B is non-negative whenever A has a greater income than B.

3. The performance of informal insurance

Our task now is to compare the best possible implementable insurance arrangement with the first-best. Since any implementable arrangement is a possible equilibrium of the game, the reader may wonder why we are focusing solely on the best of the implementable arrangements. The justification is twofold. First, the best arrangement is a natural 'focal point' and hence may be more likely to arise than any other implementable arrangement. Second, even if one does not believe this, the best arrangement provides an upper bound on the performance of informal insurance.

Without loss of generality we can confine attention to transfer arrangements which are symmetric and non-negative. The first-best, denoted $\hat{\theta}$, is defined as the set of state-contingent transfers which maximizes average expected utility allowing binding commitments. Formally, it is the solution to

[11] Note that symmetry of Θ and π implies that the expected value of the transfer is zero. Thus [illegible] player has the same expected value of post-transfer income.

the unconstrained problem of maximizing $v(\theta)$ with respect to θ. It is straightforward to verify that

$$\hat{\theta}_{ij}=(y_i-y_j)/2, \qquad i=1,\dots,n, \quad j=1,\dots,i-1.$$

Thus the first-best involves full income pooling. The best implementable contract, denoted θ^*, is the one which results in the highest average expected utility subject to the implementability constraints, i.e., θ^* is the solution to the constrained problem of maximizing $v(\theta)$ subject to eq. (3). Recall that we are restricting attention to non-negative and feasible transfer arrangements and hence the choice set is compact and convex. Since the objective function is strictly concave, we can be sure that θ^* exists and is unique. Our task now is to compare θ^* and $\hat{\theta}$.

We begin by providing a useful characterization of θ^*. First let $f(y,w)$ denote the function implicitly defined by the equation

$$u(y)-u(y-f)=w.$$

Intuitively, $f(y,w)$ can be thought of as the maximal amount of income which can be taken from a household with income y without inducing defection when the cost of defecting (in utility terms) is $w>0$. Obviously, the larger the cost of defection, the greater is the amount of income which can be taken away. In addition, diminishing marginal utility of income implies that the amount of income which can be taken away without inducing defection gets larger as the household's income increases. Thus f is increasing in both its arguments. The key point to note about the function f is that, given a particular arrangement θ, the maximal amount of income which can be taken from a household with income y without violating implementability will be given by $f(y,[v(\theta)-\bar{v}]/r)$, since it is at this transfer level that the implementability constraint is satisfied with equality.

We now have the following theorem, which underpins all the later results of the paper.

Theorem. *For all* $i=1,\dots,n$ *and* $j=1,\dots,i-1$,

$$\theta^*_{ij}=\min\{\hat{\theta}_{ij}, f(y_i,[v(\theta^*)-\bar{v}]/r)\}. \tag{4}$$

Proof. It will be convenient to use the notation θ^*/θ_{ij} to denote the vector θ^* with θ^*_{ij} replaced by θ_{ij}. We show first that if $f(y_i,[v(\theta^*)-\bar{v}]/r)\geq\hat{\theta}_{ij}$ then $\theta^*_{ij}=\hat{\theta}_{ij}$. Suppose that, on the contrary, $\theta^*_{ij}\neq\hat{\theta}_{ij}$. Now consider the vector $\theta^*/\hat{\theta}_{ij}$. Since $\partial v/\partial\theta_{ij}$ is negative for all $\theta_{ij}>\hat{\theta}_{ij}$ and positive for all $\theta_{ij}<\hat{\theta}_{ij}$, we know that $v(\theta^*/\hat{\theta}_{ij})>v(\theta^*)$. In addition, since f is increasing in its second argument it follows that

$$f(y_i,[v(\theta^*/\hat{\theta}_{ij})-\bar{v}]/r)>f(y_i,[v(\theta^*)-\bar{v}]/r)\geqq\hat{\theta}_{ij},$$

which implies that $\theta^*/\hat{\theta}_{ij}$ is implementable. Since $\theta^*/\hat{\theta}_{ij}$ is implementable and yields a higher level of expected utility, θ^* cannot be optimal – a contradiction.

We now show that $\theta^*_{ij}=f(y_i,[v(\theta^*)-\bar{v}]/r)$ if $f(y_i,[v(\theta^*)-\bar{v}]/r)<\hat{\theta}_{ij}$. Again, suppose not. Then, by implementability, it must be the case that $\theta^*_{ij}<f(y_i,[v(\theta^*)-\bar{v}]/r)$. Now choose $\tilde{\theta}_{ij}\in(\theta^*_{ij},f(y_i,[v(\theta^*)-\bar{v}]/r))$ and consider the vector $\theta^*/\tilde{\theta}_{ij}$. Since $\partial v/\partial\theta_{ij}$ is positive for all $\theta_{ij}<\hat{\theta}_{ij}$ and $\theta^*_{ij}<\tilde{\theta}_{ij}$ we know that $v(\theta^*/\tilde{\theta}_{ij})>v(\theta^*)$. Moreover, following the argument given above, it can be shown that $\theta^*/\tilde{\theta}_{ij}$ is implementable. This contradicts the optimality of θ^*. Q.E.D.

Thus, for any given income pair, the transfer under the best implementable contract either equals the first best or, if this is not implementable, the maximal implementable transfer (i.e., that which equates the gain from current defection from the arrangement with the expected gain from continued participation.)[12] Intuitively this makes good sense. If it were feasible to implement the first-best transfer for a particular income pair, then there is no good reason not to do so. If, on the other hand, this were not feasible, then one would want to get as near to the first-best as possible which would entail setting the transfer at the maximal level.

We can now establish some interesting results concerning the relationship between θ^* and $\hat{\theta}$. Under the first-best contract, all that determines the size of the net transfer between the households is the difference between their incomes. The level of incomes is irrelevant. This is not the case for the optimal informal arrangement as we show in the following proposition.

Proposition 1. *Let $y_i-y_j=y_g-y_h>0$ and let $y_i>y_g$. If $\theta^*_{ij}<\hat{\theta}_{ij}$, then*

$$\hat{\theta}_{gh}-\theta^*_{gh}>\hat{\theta}_{ij}-\theta^*_{ij}.$$

Proof. The result follows immediately from the theorem and the fact that the function f is increasing in y. Q.E.D.

Proposition 1 tells us that *if* the informal insurance arrangement diverges

[12]Our theorem makes precise Kimball's claim that 'The optimal arrangement is for grain to be transferred from those who have more than the lowest amount to those who have the least until either (1) the quantities are equalized; or (2) each of the farmers who has more than the lowest amount has contributed as much as the threat of expulsion can force him to contribute' (p. 226).

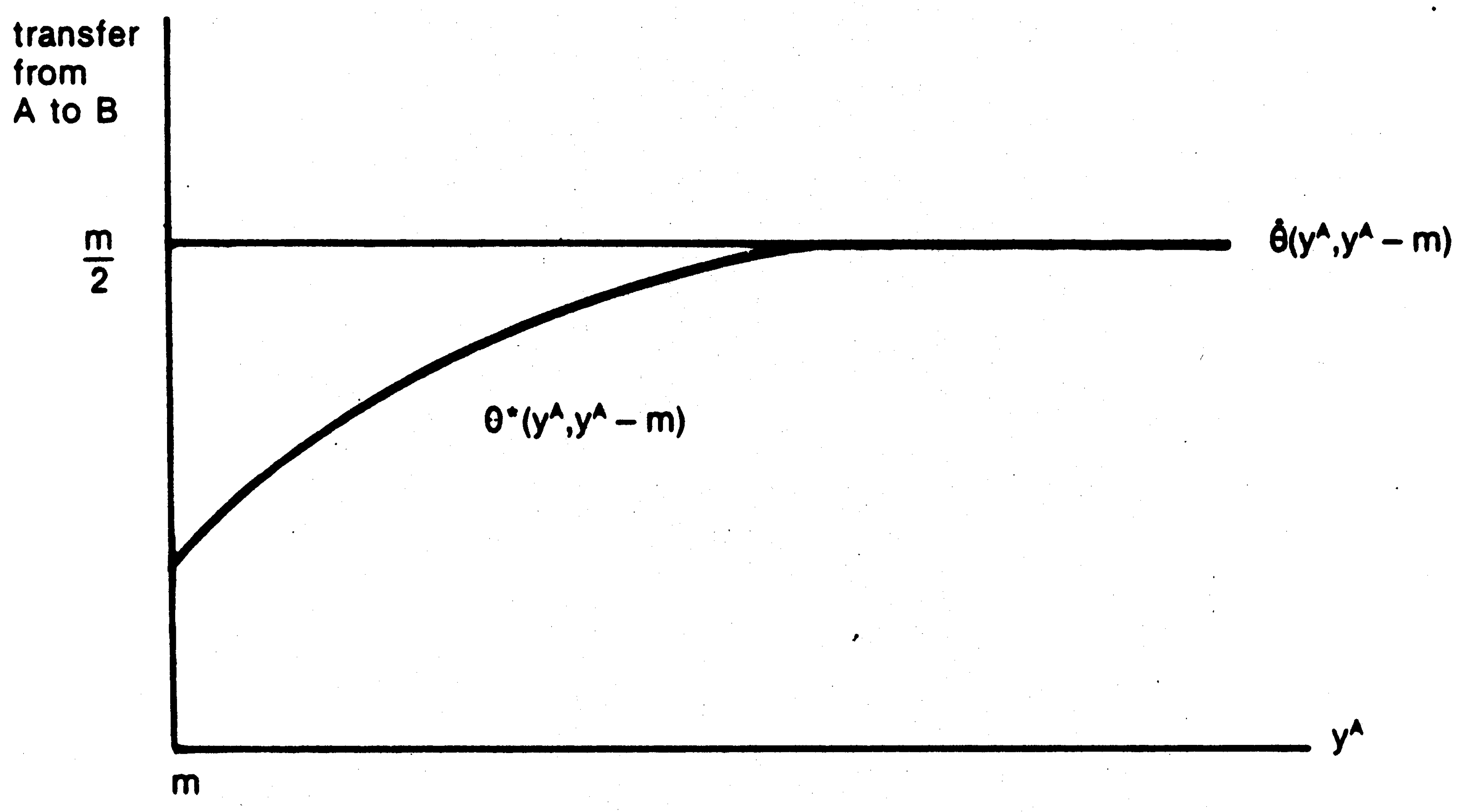

Fig. 1

from the first-best, this divergence is greatest at dates with low income levels. At low income levels, the marginal utility of income is high and hence the incentives to defect are strong. As a consequence, if the implementability constraint is already binding, then it becomes even tighter at lower income levels. The result is illustrated in fig. 1, where $\theta^*(y^A, y^B)$ denotes the informal insurance transfer and $\hat{\theta}(y^A, y^B)$ denotes the first-best.

Our next experiments involve studying the effects of changes in current (ex-post) income inequality. First suppose we fix household A's income and lower B's income. Under our assumptions, the first-best arrangement has the property that A will always transfer one half of the income difference to B. The following proposition tells us what happens to the optimal informal insurance arrangement as B's income lowers.

Proposition 2. *Let $y_i > y_j > y_h$. Then, if $\theta^*_{ij} < \hat{\theta}_{ij}$, $\theta^*_{ih} = \theta^*_{ij}$.*

Proof. Since $y_h < y_j$, we have that $\hat{\theta}_{ih} > \hat{\theta}_{ij}$. It follows from the theorem that $\theta^*_{ih} = f(y_i, [v(\theta^*) - \bar{v}]/r)$. Q.E.D.

Thus, once the implementability constraint bites, there is no scope for additional transfers no matter how low B's income falls. As a consequence, post transfer income inequality will exist and will increase as the income divergence grows. This is illustrated in fig. 2.

Finally, let's fix household B's income and increase household A's. Under the first-best contract, household A transfers exactly one half of the difference to household B. What happens under the optimal informal arrangement? The following proposition is established in the appendix.

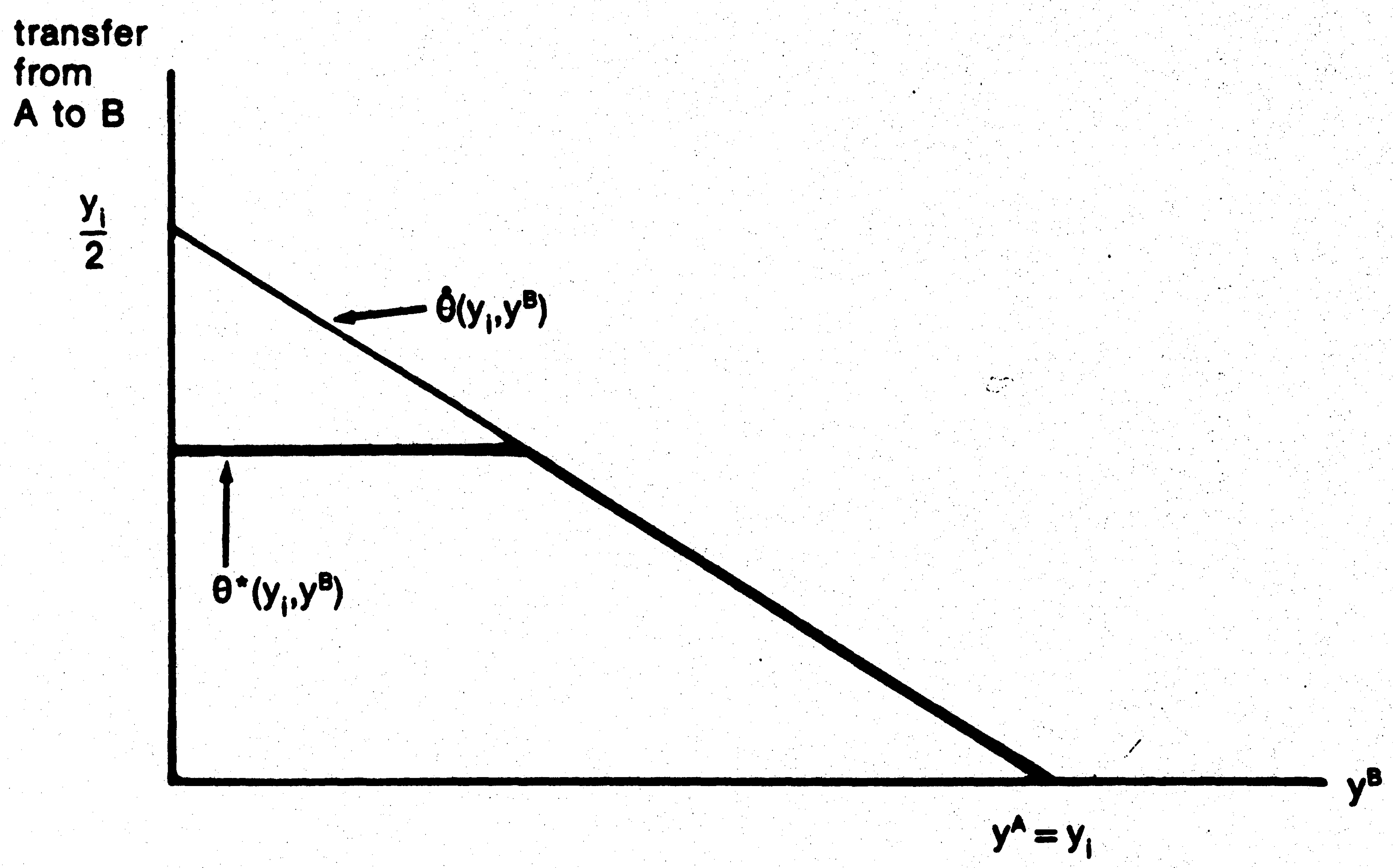

Fig. 2

Proposition 3. *Let* $y_i > y_g > y_h$ *and suppose that* $1/u'(y)$ *is concave. If* $\theta^* \neq 0$ *and* $\theta^*_{gh} < \hat{\theta}_{gh}$, *then* $\hat{\theta}_{ih} - \theta^*_{ih} > \hat{\theta}_{gh} - \theta^*_{gh}$.

Thus if the utility function satisfies the stated property and if the informal arrangement diverges from the first-best, then this divergence will increase as household A's income increases, holding B's constant. This is illustrated in fig. 3.

The condition that $1/u'(y)$ is concave in y is satisfied by a reasonably broad class of utility functions.[13] For example, the constant relative risk aversion utility function $u(y) = y^{1-\rho}/(1-\rho)$ has this property for $\rho \in (0, 1]$. If the utility function does not have this property, however, it is possible that the difference between the first-best and the informal insurance arrangement can close after some point, as illustrated in fig. 4. On the one hand, as the income difference grows, the first-best transfer increases which makes implementability more difficult. But, on the other hand, diminishing marginal utility of income implies that the utility cost of a given transfer decreases as income increases.

The preceding three propositions all have the same basic form. Assuming that the optimal informal arrangement diverges from the first-best, they tell us how this divergence behaves. Proposition 1 tells us that it increases as income levels fall; Proposition 2 tells us that it increases as B's income falls,

[13]The importance of the concavity or convexity of $1/u'$ arises in a number of other incentive problems [for example, Rogerson (1985)].

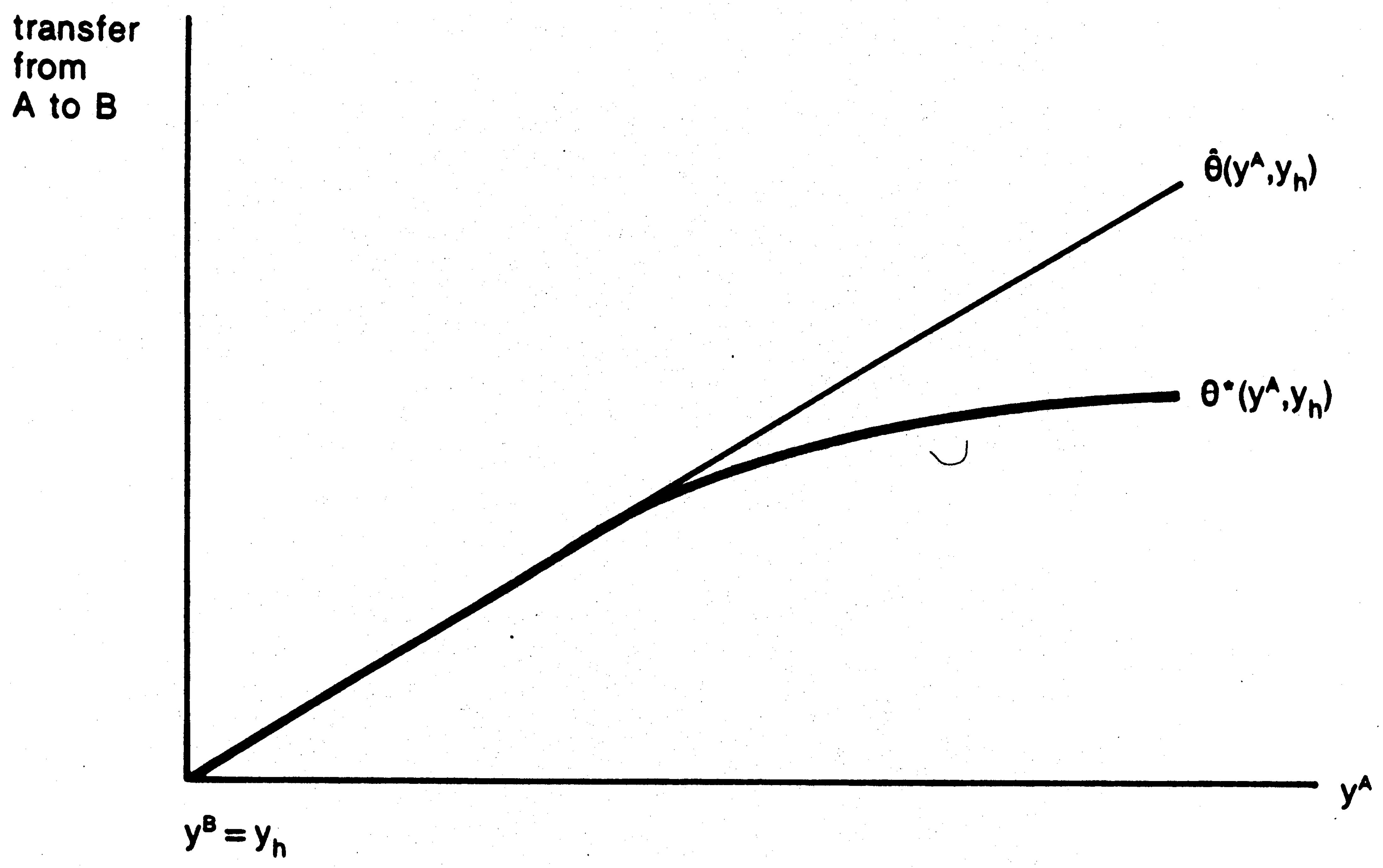

Fig. 3

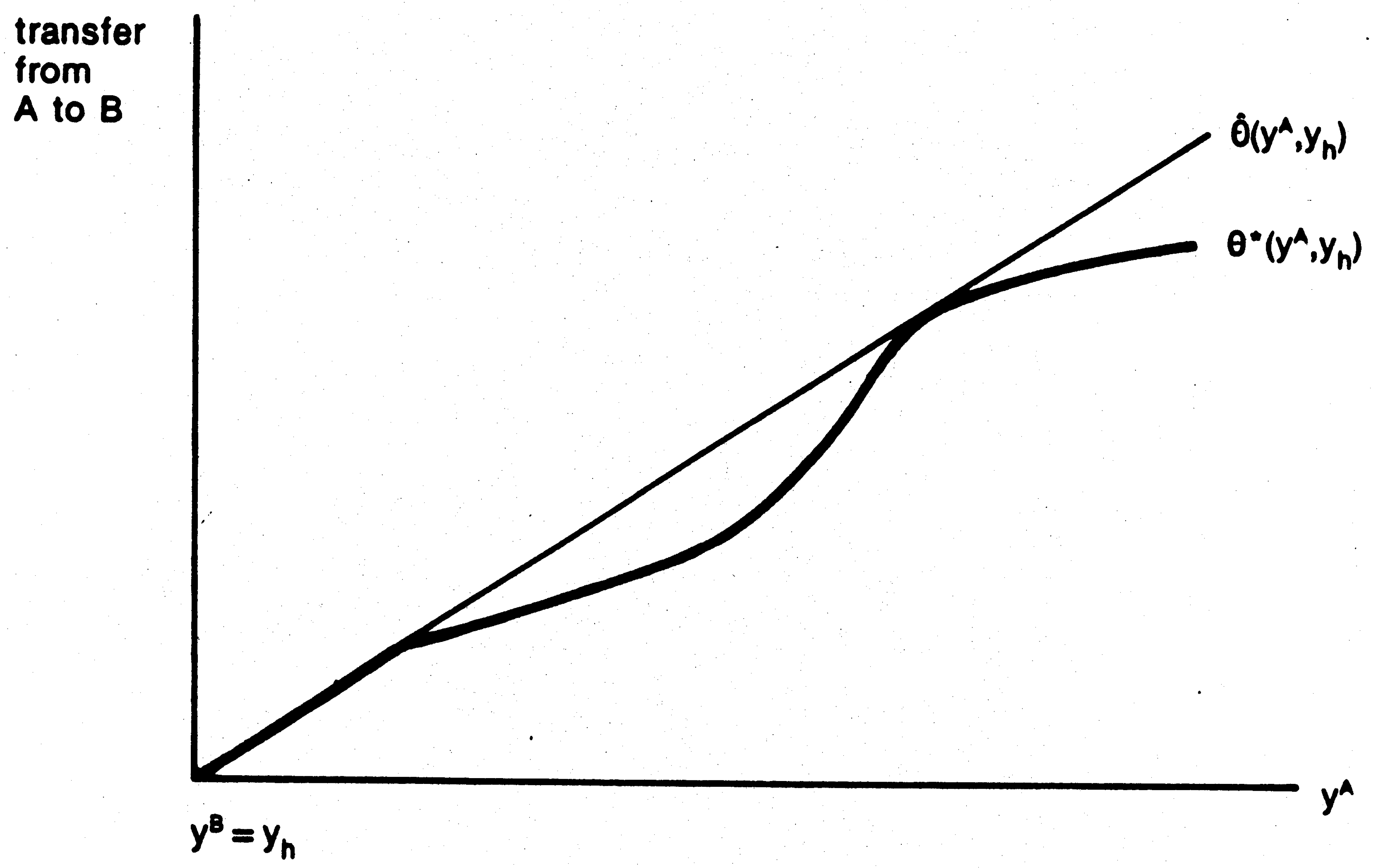

Fig. 4

holding A's income constant; and Proposition 3 gives a condition under which the divergence increases as A's income increases holding B's constant. Note that these results do not tell us that the optimal informal arrangement necessarily diverges from the first-best, even at very low or unequal income pairs. Kimball establishes some results which speak directly to this issue. Assuming that households' utility functions have the constant relative risk aversion form, he finds that unless ρ – the risk aversion parameter – is equal to 1 there will always exist some income pair (y^A, y^B) at which full sharing is not implementable no matter what the gains in expected utility from full risk sharing.[14] As he explains 'when $\rho<1$, diminishing marginal utility is weak enough that a very fortunate farmer enjoys feasting on his hoard so much that he cannot be induced to share it all. On the other hand, when $\rho>1$, poverty is so painful that when all farmers in the cooperative are doing badly, but one is doing a little better than the others, he cannot be induced to share all of his pitfall pile' (p. 229). For the case $\rho=1$ he shows that full sharing can be achieved (for all conceivable income pairs) if households are sufficiently patient and if they face sufficient variability in their incomes.

4. Comparative static properties

In this section we investigate how the optimal informal insurance arrangement varies with some of the exogenous variables of the model. Specifically, we examine the effects of changes in the households' discount rates and the probability distribution over incomes. Our results should shed light on the circumstances under which the divergences between the optimal informal arrangement and the first-best are greatest.

We began with the discount rate which, it will be recalled, is denoted r. Kimball's computations for the constant relative risk aversion case suggest that risk-sharing institutions are less likely to form the more impatient are households. This makes good sense intuitively, since the benefits from being in a risk-sharing arrangement are enjoyed in the future. Thus we would expect the divergence between the first-best transfer and the optimal informal transfer at any income level to increase as the discount rate falls. This is confirmed in the following proposition. The notation $\theta^*(r)$ denotes the optimal implementable contract when the discount rate is r.

Proposition 4. *Let $r^0<r^1$ and suppose that $\theta^*(r^1)\neq 0$. Then $\theta^*_{ij}(r^1)\leqq\theta^*_{ij}(r^0)$, with the inequality holding strictly if $\theta^*_{ij}(r^1)<\hat{\theta}_{ij}$.*

Proof. It is clear that $\theta^*(r^1)$ is implementable when the discount rate is r^0 and hence that $v(\theta^*(r^0))\geqq v(\theta^*(r^1))$. It follows therefore that $[v(\theta^*(r^0))-\bar{v}]/r^0$ exceeds $[v(\theta^*(r^1))-\bar{v}]/r^1$. Since f is increasing in its second argument the result now follows from the theorem. Q.E.D.

[14]In terms of our notation, Kimball shows that if $\rho\neq 1$, for all $w>0$ there exists (y^A, y^B) such that $f(y^A, w)<(y^A-y^B)/2$.

As was pointed out earlier, the discount rate will reflect households' assessment of the probability of playing the game in the future. Another way of interpreting this result, therefore, is that if households do not expect to be playing the game for long the divergence between the optimal arrangement and the first-best will be large. This suggests that as traditional societies become more mobile, so that future generations are less likely to be in close contact, the moral economy will tend to perform less well. A further important influence on the discount rate is the expected length of time between income draws. If the income draws we are talking about are harvests, this frequency may be annual or biannual. Clearly, more frequent draws correspond to a lower discount rate.

Let us now consider perturbing the probability distribution $\pi=(\pi_{ij})$. One would expect informal insurance to perform poorly if it was unlikely that the households would earn different incomes. For then the potential risk-sharing gains would be small, and there would be less incentive not to defect. Thus one can conjecture that the divergences between the optimal informal arrangement and the first-best will be greater when participants face more covariate income streams. To investigate this possibility we analyze the performance of informal insurance under two probability distributions which differ in the weight they give to divergent incomes. Let $\theta^*(\pi)$ denote the optimal arrangement associated with the probability distribution π. We now have the following proposition a proof of which can be found in the appendix.

Proposition 5. *Let π^0 and π^1 be two probability distributions such that*

(i) $\sum_{j=1}^{n}(\pi_{ij}^1-\pi_{ij}^0)=0$ *and*
(ii) $\pi_{ij}^1<\pi_{ij}^0$ *for all* $i\neq j$.

If $\theta^*(\pi^1)\neq 0$, *then* $\theta_{ij}^*(\pi^1)\leq\theta_{ij}^*(\pi^0)$ *with the inequality holding strictly if* $\theta_{ij}^*(\pi^1)<\hat{\theta}_{ij}$.

Thus in situations where the optimal arrangement diverges from the first-best, a decrease in the probability of different incomes will increase the divergence.

5. Numerical simulations of informal insurance

The results of the previous two sections provide a reasonably complete picture of the qualitative properties of informal insurance. In this section we supplement these results by simulating optimal informal insurance arrangements under alternative assumptions on the relevant parameters. This will allow us to form a clearer picture of the likely quantitative significance of the divergences from the first-best solution in specific circumstances. It will also shed light on the arrangement's analytically ambiguous properties. The parameters focused on are the probability distribution over incomes, the discount rate, and the players' aversion to risk.

The main task is to solve eq. (4) for an explicit utility function and given parameter values. For this purpose we assume a constant relative risk aversion utility function $u(y)=y^{(1-\rho)}/(1-\rho)$. While eq. (4) does not yield an explicit solution for the optimal implementable transfers, it can be solved numerically. Let $\theta^*(t)$ denote the estimated vector of transfers obtained at the tth iteration, and set $\theta^*(0)=\hat{\theta}$, being the first-best transfers. Then up-date these estimates at each iteration using

$$\theta^*_{ij}(t+1)=\min\{\hat{\theta}_{ij}, y_i-[y_i^{1-\rho}-(v(\theta^*(t))-\bar{v})/r]^{1/(1-\rho)}\}. \tag{5}$$

Convergence then implies that (4) is satisfied.[15]

Since our sole aim here is to give a simple illustration, we assume only three possible incomes, $y_1=1$, $y_2=2$, $y_3=3$. The corresponding first-best transfers are then $\hat{\theta}_{21}=0.5$, $\hat{\theta}_{31}=1$ and $\hat{\theta}_{32}=0.5$. Three joint probability distributions are considered ranging from 'highly covariate' to 'highly non-covariate', where the less covariate distribution is obtained from the more covariate one by transfers of density from diagonal to off-diagonal elements. Specifically the three possible distributions are

(i) The 'highly covariate' income stream:

$$\pi_{11}=\pi_{33}=0.2,\ \pi_{22}=0.3,\ \pi_{12}=\pi_{13}=\pi_{23}=0.05;$$

(ii) The 'moderately covariate' income stream:

$$\pi_{22}=0.2,\ \pi_{11}=\pi_{33}=\pi_{12}=\pi_{13}=\pi_{23}=0.1;$$

(iii) The 'highly non-covariate' income stream:

$$\pi_{11}=\pi_{22}=\pi_{33}=\pi_{12}=\pi_{23}=0.1,\ \pi_{13}=0.15.$$

Tables 1, 2, and 3 give the informal transfers implied by a wide range of parameter values for the discount rate and relative risk aversion parameters.[16] Although evidence is scarce (and often conflicting), values for

[15]A copy of a Fortran program implementing this algorithm is available for use on a PC with the DOS operating system. It is set-up in a user-friendly mode.

[16]The convergence criterion is that successive estimates are within 0.1 percent of each other. This was generally achieved within twenty or so iterations.

Table 1

Equilibrium transfers for highly covariate income streams.[a,b]

Discount rate r	Risk aversion ρ	Transfers θ^*_{21}	θ^*_{31}	θ^*_{32}	Proportional gain γ
0.05	0.1	0	0	0	0
0.05	0.3	0	0	0	0
0.05	0.5	0.262	0.323	0.323	0.649
0.05	0.7	0.500	0.687	0.500	0.942
0.05	0.9	0.500	0.963	0.500	0.999
0.15	0.1	0	0	0	0
0.15	0.3	0	0	0	0
0.15	0.5	0	0	0	0
0.15	0.7	0	0	0	0
0.15	0.9	0	0	0	0
0.15	1.1	0.180	0.280	0.280	0.569
0.15	1.3	0.299	0.500	0.500	0.819
0.15	1.5	0.386	0.686	0.500	0.934
0.15	1.7	0.452	0.846	0.500	0.986
0.15	1.9	0.500	0.982	0.500	1.00
0.15	2.1	0.500	1.00	0.500	1.00
0.25	0.1	0	0	0	0
0.25	0.3	0	0	0	0
0.25	0.5	0	0	0	0
0.25	0.7	0	0	0	0
0.25	0.9	0	0	0	0
0.25	1.1	0	0	0	0
0.25	1.3	0.034	0.058	0.058	0.142
0.25	1.5	0.149	0.271	0.271	0.544
0.25	1.7	0.234	0.451	0.451	0.761
0.25	1.9	0.299	0.608	0.500	0.879
0.25	2.1	0.353	0.750	0.500	0.946
0.25	2.3	0.398	0.875	0.500	0.981
0.25	2.5	0.435	0.985	0.500	0.995
0.25	2.7	0.500	1.00	0.500	1.00

[a] $\pi_{11}=0.2$, $\pi_{12}=0.05$, $\pi_{22}=0.3$, $\pi_{13}=0.05$, $\pi_{23}=0.05$, $\pi_{33}=0.2$.
[b] First-best transfers: $\hat{\theta}_{21}=0.5$, $\hat{\theta}_{31}=1.0$, $\hat{\theta}_{32}=0.5$.

relative risk aversion of around 0.5–1.0 in poor agrarian settings are not implausible.[17] We give results for all values of ρ up to that at which informal insurance achieves first-best risk sharing. Results are given for discount rates of 5%, 15% and 25%; the latter figure may well be quite realistic in underdeveloped rural economies [see Pender and Walker (1989)]. The tables also give a useful measure of performance relative to the cooperative solution, namely the *proportional gain*, γ, defined by

[17] See Binswanger's (1978) experimental results for rural India. Newbery and Stiglitz (1981) discuss this study and other evidence on peasants' risk aversion in poor countries. Kimball discusses evidence for other settings, though estimates vary.

Table 2

Equilibrium transfers for moderately covariate income streams.[a]

Discount rate r	Risk aversion ρ	Transfers θ^*_{21}	θ^*_{31}	θ^*_{32}	Proportional gain γ
0.05	0.1	0	0	0	0
0.05	0.3	0.365	0.415	0.415	0.767
0.05	0.5	0.500	0.934	0.500	0.997
0.05	0.7	0.500	1.00	0.500	1.00
0.05	0.9	0.500	1.00	0.500	1.00
0.15	0.1	0	0	0	0
0.15	0.3	0	0	0	0
0.15	0.5	0	0	0	0
0.15	0.7	0.253	0.338	0.338	0.664
0.15	0.9	0.424	0.628	0.500	0.916
0.15	1.1	0.500	0.857	0.500	0.989
0.15	1.3	0.500	1.00	0.500	1.00
0.25	0.1	0	0	0	0
0.25	0.3	0	0	0	0
0.25	0.5	0	0	0	0
0.25	0.7	0	0	0	0
0.25	0.9	0.123	0.177	0.177	0.398
0.25	1.1	0.283	0.440	0.440	0.770
0.25	1.3	0.390	0.649	0.500	0.920
0.25	1.5	0.469	0.827	0.500	0.983
0.25	1.7	0.500	1.00	0.500	1.00

[a] $\pi_{11}=\pi_{12}=0.1$, $\pi_{22}=0.2$, $\pi_{13}=\pi_{23}=\pi_{33}=0.1$.

$$\gamma=\frac{v(\theta^*)-\bar{v}}{v(\hat{\theta})-\bar{v}}.$$

Tables 1–3 nicely illustrate our previous results. Since $y_2-y_1=y_3-y_2$, our claim that income levels matter can be verified by comparing θ^*_{21} and θ^*_{32}. As predicted, if θ^*_{32} is less than the first-best transfer then θ^*_{21} is always less than θ^*_{32}. Thus lower income levels result in greater divergences from the first-best. Proposition 2 is verified by comparing θ^*_{31} and θ^*_{32}. If θ^*_{32} is less than the first-best transfer 0.5, then θ^*_{31} equals θ^*_{32} as predicted. Thus the transfer from household A to household B flattens out as B's income falls. Finally, Proposition 3 can be verified by comparing θ^*_{21} and θ^*_{31}. We find, as predicted for utility functions in which $1/u'(y)$ is concave, the divergence from first-best increases as A's income rises for all ρ in this interval. (Indeed, this also happens when the risk aversion coefficient exceeds one). Similarly, these results illustrate our comparative static results. The performance of informal insurance improves as the discount rate falls and as the income distribution become less covariate.

Note also that higher degrees of risk aversion are found to be associated

Table 3

Equilibrium transfers for highly noncovariate income streams.[a]

Discount rate r	Risk aversion ρ	Transfers θ^*_{21}	θ^*_{31}	θ^*_{32}	Proportional gain γ
0.05	0.1	0	0	0	0
0.05	0.3	0.500	0.649	0.500	0.914
0.05	0.5	0.500	1.00	0.500	1.00
0.05	0.7	0.500	1.00	0.500	1.00
0.05	0.9	0.500	1.00	0.500	1.00
0.15	0.1	0	0	0	0
0.15	0.3	0	0	0	0
0.15	0.5	0.132	0.162	0.162	0.362
0.15	0.7	0.426	0.570	0.500	0.872
0.15	0.9	0.500	0.857	0.500	0.987
0.15	1.1	0.500	1.00	0.500	1.00
0.25	0.1	0	0	0	0
0.25	0.3	0	0	0	0
0.25	0.5	0	0	0	0
0.25	0.7	0.059	0.078	0.078	0.186
0.25	0.9	0.288	0.415	0.415	0.735
0.25	1.1	0.438	0.665	0.500	0.925
0.25	1.3	0.500	0.866	0.500	0.989
0.25	1.5	0.500	1.00	0.500	1.00

[a] $\pi_{11}=\pi_{12}=\pi_{22}=\pi_{23}=\pi_{33}=0.1$, $\pi_{13}=0.15$.

with a relatively better (or no worse) performance. This is consonant with the results of Kimball who reports that the discount rate above which no risk sharing is possible is increasing in ρ. The relationship between γ and ρ for $r=0.10$ and the moderately covariate income stream is depicted in fig. 5. (The pattern of concavity beyond some critical value is the same for other parameter combinations). Risk sharing only exists for $\rho \geqq 0.38$. With increasing risk aversion beyond that point, relative performance improves rapidly, though flattening at high levels of risk aversion.

One striking feature of the results in tables 1–3 is how sharply the performance varies. Even a quite successful risk-sharing arrangement may vanish with certain seemingly modest perturbations to parameter values, such as a small decline in the participants' aversion to risk. Thus Foster's conclusion that family based risk-sharing arrangements are likely to be 'highly unstable' (pp. 34–35) appears robust to allowing households to make partial transfers. What causes these sharp variations in performance? The implementability constraints imply that transfers must be reduced below the first-best level. But once transfers have been reduced, there is less incentive to participate and hence the implementability constraints tighten. This necessit-

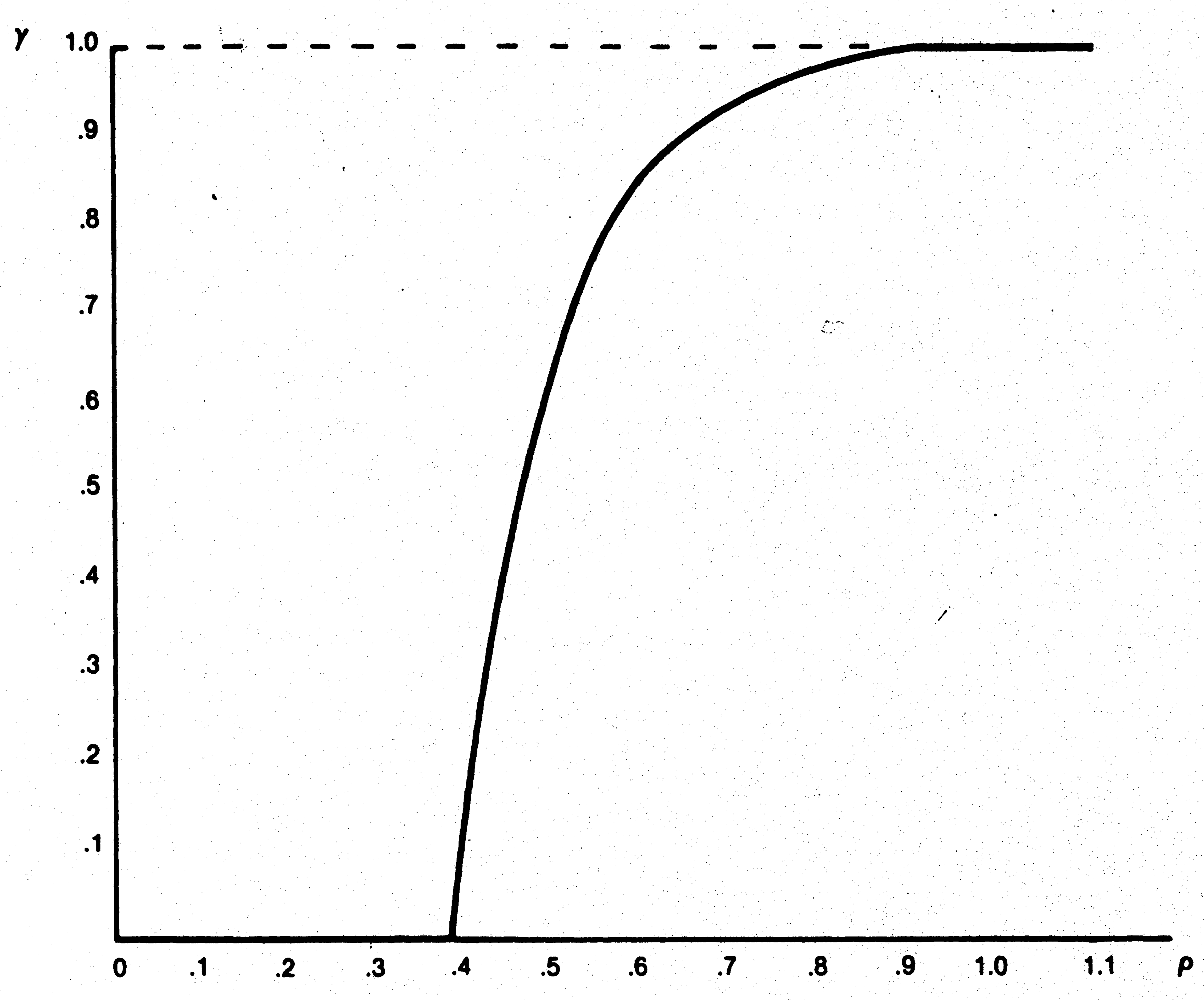

Fig. 5

ates a further reduction in transfers. This process can easily converge to zero transfers. The implication of this variability is that we might expect to find wildly divergent performances of the moral economy in apparently similar communities.

6. Suggestions for further research

The analysis in this paper could be usefully extended in a number of different ways. First, one could allow households to use non-stationary insurance arrangements; that is, arrangements whose transfers may depend on both current and past income realizations. These are of interest because they allow an element of lending in informal insurance arrangements. A household who has received a transfer may 'pay back' the donor household by agreeing to a less favorable transfer arrangement in future periods. This may bring forth a larger transfer from the donor household and hence result in improved risk-sharing. [Platteau and Abraham (1988) have noted the quasi-credit nature of some informal risk-sharing arrangements in practice.]

While characterizing the optimal non-stationary insurance arrangement represents a more challenging analytical task, Thomas and Worall (1988) have analyzed a formally similar problem in wage contract theory and the techniques they have developed should prove helpful.

Another extension would be to relax the assumption that households cannot save. Savings represent another way households can insure against income shocks. It is by no means obvious how the introduction of self-insurance possibilities would affect the nature of informal social insurance. A household's ability to give, or its need for transfers, would depend not only on its income but also on its past savings. Self-insurance may displace social insurance in some circumstances, although there will still (in principle) exist potential gains from informal insurance.

A further extension would be to allow a household's income to depend on its work effort, and in a way which others in the community cannot observe. This would introduce an element of moral hazard into the problem; that is, households may have an incentive to slack off knowing that they will receive an income transfer. This is likely to be more of a problem in urban communities than in village economies where individuals can observe each other fairly closely. An optimal informal insurance arrangement will naturally take into account any such asymmetries in information. This may alter some of our results; for example, as a referee has suggested, the presence of moral hazard may invalidate our finding that the optimal informal arrangement achieves first-best risk sharing for small income differences.

Finally, it might be interesting to relax the assumption that households face identical income distribution. What type of arrangements would arise between a rich and poor household? A referee has suggested that one might expect implementable arrangements to favor the richer household. They may then be 'exploitative' in some appropriately defined sense. The logic behind this view is that, because the poorer household has more to gain from insurance, the implementability constraints will be tighter for the richer household. However, it must be remembered that diminishing marginal utility of income will imply that the poorer household has more short-run incentive to deviate.

7. Conclusions

Community wide participation in various informal risk-sharing practices is a common feature of traditional rural societies. These practices can be perfectly reasonable and sustainable strategies in the absence of suitable and widely accessible risk markets and legal institutions enabling explicit and enforceable contracts. This does not mean, however, that such arrangements will be particularly good risk-sharing institutions. Even without problems of asymmetric information, the constraint imposed by implementability without commitment will generally reduce performance relative to first-best risk sharing.

This paper has used a simple model to better understand precisely how informal insurance arrangements are likely to diverge from first-best risk sharing. Our analysis suggests that such divergences will be larger in many situations where insurance is badly needed, such as at dates when incomes are generally low, or those at which a few incomes are low, generating high current inequality. It also suggests that these divergences will tend to be greater in societies in which different incomes are less likely and time preference rates are high. Furthermore, our numerical simulations suggest that informal arrangements may be quite sensitive to small changes in initial conditions. An active informal insurance arrangement may vanish entirely with a seemingly small drop in the players' aversion to risk or an increase in their discount rate. Thus our inquiry throws light on the circumstances in which non-market insurance may exist, and how well it will perform.

Appendix

Proof of Proposition 3

Define the function

$$g(y)=(y-y_h)/2-f(y,[v(\theta^*)-\bar{v}]/r).$$

Since $\theta^*_{gh}<\hat{\theta}_{gh}$, the theorem tells us that $\theta^*_{gh}=f(y_g,[v(\theta^*)-\bar{v}]/r)$. In addition, $\hat{\theta}_{gh}=(y_g-y_h)/2$ and hence we have that $g(y_g)=\hat{\theta}_{gh}-\theta^*_{gh}>0$. Suppose we could show that $g(y_i)>g(y_g)$. Then, since $\hat{\theta}_{ih}=(y_i-y_h)/2$, $\hat{\theta}_{ih}>f(y_i,[v(\theta^*)-\bar{v}]/r)$ which implies by the theorem that $g(y_i)=\hat{\theta}_{ih}-\theta^*_{ih}$ and hence that $\hat{\theta}_{ih}-\theta^*_{ih}>\hat{\theta}_{gh}-\theta^*_{gh}$, which is the result we want to prove. Thus it suffices to show that $g(y_i)>g(y_g)$. Note first that

$$g''(y)=-f_{11}(y,[v(\theta^*)-\bar{v}]/r).$$

It is straightforward to verify that if $1/u'(y)$ is concave, $f_{11}\leqq 0$ and hence that $g''(y)\geqq 0$. We know that $g(y_g)>0$. In addition, it is clear that $g(y_h)<0$. It follows that there must exist some $y^*\in(y_h,y_g)$ such that $g'(y^*)>0$. But since $g''(y)\geqq 0$, this implies that $g'(y)>0$ for all $y\geqq y^*$. It follows that $g(y_i)>g(y_g)$. Q.E.D.

Proof of Proposition 5

In what follows we recognize the dependence of expected utility on π, by writing $v(\theta,\pi)$. We know by the theorem that, for all π,

$$\hat{\theta}_{ij}(\pi)=\min\{\hat{\theta}_{ij}, f(y_i,[v(\theta^*(\pi),\pi)-\bar{v}(\pi)]/r)\}.$$

Since f is increasing in its second argument it therefore suffices to show that

$$[v(\theta^*(\pi^0),\pi^0)-\bar{v}(\pi^0)]/r>[v(\theta^*(\pi^1),\pi^1)-\bar{v}(\pi^1)]/r.$$

We begin by proving that for any non-zero non-negative vector $\theta\leqq\hat{\theta}$,

$$v(\theta,\pi^0)>v(\theta,\pi^1).$$

To see this, note that

$$v(\theta,\pi^0)-v(\theta,\pi^1)=\sum_{i=1}^{n}\left[\sum_{j=1}^{i-1}(\pi_{ij}^0-\pi_{ij}^1)(u(y_i-\theta_{ij})+u(y_j+\theta_{ij}))\right.$$
$$\left.+(\pi_{ii}^0-\pi_{ii}^1)u(y_i)\right].$$

By condition (i) of the proposition we know that, for all $i=1,\dots,n$,

$$\pi_{ii}^0-\pi_{ii}^1=-\sum_{j\neq i}(\pi_{ij}^0-\pi_{ij}^1).$$

Thus

$$v(\theta,\pi^0)-v(\theta,\pi^1)=\sum_{i=1}^{n}\left[\sum_{j=1}^{i-1}(\pi_{ij}^0-\pi_{ij}^1)(u(y_i-\theta_{ij})+u(y_j+\theta_{ij}))\right.$$
$$\left.-\sum_{j=1}^{i-1}(\pi_{ij}^0-\pi_{ij}^1)u(y_i)-\sum_{j=i+1}^{n}(\pi_{ij}^0-\pi_{ij}^1)u(y_i)\right]$$
$$=\sum_{i=1}^{n}\left[\sum_{j=1}^{i-1}(\pi_{ij}^0-\pi_{ij}^1)(u(y_i-\theta_{ij})+u(y_j+\theta_{ij})\right.$$
$$\left.-u(y_i)-u(y_j))\right],$$

where the last equality follows by symmetry. Since $\pi_{ij}^0>\pi_{ij}^1$ for all $j=1,\dots,i-1$, and $u(y_i-\theta_{ij})+u(y_j+\theta_{ij})\geqq u(y_i)+u(y_j)$ for all $\theta_{ij}\in[0,\hat{\theta}_{ij}]$ with strict inequality if $\theta_{ij}>0$, the result follows.

From the above result, we know that

$$v(\theta^*(\pi^1),\pi^0) > v(\theta^*(\pi^1),\pi^1).$$

Since $\bar{v}(\pi^1)=\bar{v}(\pi^0)$, this implies that $\theta^*(\pi^1)$ is implementable when the probability distribution is π^0. Thus

$$[v(\theta^*(\pi^0),\pi^0)-\bar{v}(\pi^0)]/r \geq [v(\theta^*(\pi^1),\pi^0)-\bar{v}(\pi^0)]/r$$

$$> [v(\theta^*(\pi^1),\pi^1)-\bar{v}(\pi^1)]/r. \qquad \text{Q.E.D.}$$

References

Abreu, Dilip, 1988, On the theory of infinitely repeated games with discounting, Econometrica 56, 383–396.

Basu, Kaushik, 1987, Modelling finitely-repeated games with uncertain termination, Economics Letters 23, 147–151.

Binswanger, Hans P., 1978, Attitudes toward risk: Experimental measurement evidence in rural India, American Journal of Agricultural Economics 395–407.

Caldwell, John C., P.H. Reddy and Pat Caldwell, 1986, Periodic high risk as a cause of fertility decline in a changing rural environment: Survival strategies in the 1980–1983 South Indian drought, Economic Development and Cultural Change 677–701.

Coate, Stephen and Martin Ravallion, 1989, Reciprocity without commitment: Characterization and performance of informal risk-sharing arrangements, Discussion paper no. 96 (Development Economics Research Center, University of Warwick, Coventry).

Currey, Bruce, 1981, The famine syndrome: Its definition for relief and rehabilitation in Bangladesh, in: J. Robson, ed., Famine: Its causes, effects and management (Gordon and Breach, New York).

Dirks, R., 1980, Social responses during severe food shortages and famine, Current Anthropology 21.

Drèze, Jean and Amartya Sen, 1989, Hunger and public action (Oxford University Press, Oxford).

D'Souza, Frances, 1988, Famine: Social security and an analysis of vulnerability, in: G. Ainsworth Harrison, ed., Famine (Oxford University Press, Oxford).

Epstein, Scarlett, 1967, Productive efficiency and customary systems of reward in rural South India, in: R. Firth, ed., Themes in economic anthropology (Tavistock, London).

Foster, Andrew, 1988, Why things fall apart: A strategic analysis of repeated interaction in rural financial markets, Mimeo. (Department of Economics, University of California at Berkeley, Berkeley, CA).

Friedman, James, 1986, Game theory with applications to economics (Oxford University Press, Oxford).

Greenough, Paul R., 1982, Prosperity and misery in modern Bengal: The famine of 1943–49 (Oxford University Press, Oxford).

Kaufman, Daniel, and David L. Lindauer, 1984, Income transfers within extended families to meet basic needs: The evidence from El Salvador, World Bank staff working paper no. 644 (World Bank, Washington, DC).

Kimball, Miles, 1988, Farmers' cooperatives as behavior toward risk, American Economic Review 78, 224–232.

Newbery, David M.G., 1989, Agricultural institutions for insurance and stabilization, in: Pranab Bardhan, ed., The economic theory of agrarian institutions (Oxford University Press, Oxford).

Newbery, David M.G. and Joseph E. Stiglitz, 1981, The theory of commodity price stabilization (Oxford University Press, Oxford).

Pender, John L. and Thomas Walker, 1989, Experimental measurement of time preferences in rural India, Mimeo. (Food Research Institute, Stanford University, Stanford, CA).

Platteau, Jean-Philippe, 1988, Traditional systems of social security and hunger insurance: Some lessons from the evidence pertaining to third world village societies, Working paper no. 15 (The Development Economics Research Programme, London School of Economics, London).

Platteau, Jean-Philippe and Anita Abraham, 1987, An inquiry into quasi-credit contracts: The role of reciprocal credit and interlinked deals in small-scale fishing communities, Journal of Development Studies 23, 461–490.

Popkin, Samuel L., 1979, The rational peasant, The political economy of rural society in Vietnam (University of California Press, Berkeley).

Posner, Richard A., 1980, A theory of primitive society, with special reference to law, The Journal of Law and Economics 23, 1–53.

Ravallion, Martin, 1987, Markets and famines (Oxford University Press, Oxford).

Ravallion, Martin and Chaudhuri Shubham, 1991, Testing risk-sharing in three Indian villages, Mimeo. (World Bank, Washington, DC).

Ravallion, Martin and Lorraine Dearden, 1988, Social security in a 'moral economy': An empirical analysis for Java, The Review of Economics and Statistics 70, 36–44.

Rogerson, William, 1985, Repeated moral hazard, Econometrica 53, 69–76.

Rosenzweig, Mark, 1988, Risk, implicit contracts and the family in rural areas of low-income countries, The Economic Journal 98, 1148–1170.

Scott, James, 1976, The moral economy of the peasant. Rebellion and subsistence in Southeast Asia (Yale University Press, New Haven, CT).

Sen, Amartya, 1981, Poverty and famines, An essay on entitlement and deprivation (Oxford University Press, Oxford).

Sugden, Robert, 1986, The economics of rights, cooperation and welfare (Basil Blackwell, Oxford).

Thomas, Jonathan and Tim Worrall, 1988, Self-enforcing wage contracts, Review of Economic Studies 60, 541–554.

Thomas, R., Brooke, Sabrina H.B.H. Paine and Barrett O. Brenton, 1989, Perspectives on socio-economic causes of and responses to food deprivation, Food and Nutrition Bulletin 11, 41–54.

Townsend, Robert M., 1991, Risk and insurance in village India, Mimeo. (University of Chicago, Chicago, IL).

Watts, Michael, 1983, Silent violence, Food, famine and peasantry in Northern Nigeria (University of California Press, Berkeley, CA).