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Consumption Smoothing and Extended Families

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ABSTRACT

In this paper we look at various issues pertaining the smoothing of consumption in *village economies* (small agricultural societies). We discuss how consumption smothing is possible despite the lack of enforceability of private contracts. We next discuss how outside institutions may affect the total provision of insurance both directly (via its own policies) and indirectly (via the changes that its policies induce in private behavior), and show how it is possible that well intentioned policies may reduce welfare because they destroy the social fabric of private insurance arrangements. Further we discuss how certain policies may improve welfare because they reinforce the social fabric. We also discuss the empirical implications of the models we consider. We show ample evidence that in traditional societies the allocations are far from the first best and at the same time there is ample, if incomplete, insurance provided not by the market, but by immediate members of society.

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1 Introduction

Agricultural economies are characterised by substantial fluctuations in individual income. Some of these fluctuations affect all members of the society, while others are individual specific. Income fluctuations do not have to translate into consumption fluctuations (that people abhor given convex preferences). However, all too often income fluctuations induce (perhaps mitigated) consumption fluctuations. Moreover, there is evidence that idiosyncratic risk is not fully insured even within relatively small and closed groups. Udry (1994), for instance, discussing his evidence from rural Nigeria, states that 'it is possible to reject the hypothesis that a fully Pareto-efficient risk-pooling allocation of village resources is achieved through these loans. The mutual insurance network available through these loans to households in rural northern Nigeria is important, but it is incomplete.' (p.523)

We think of agricultural societies (villages, islands) as both having undeveloped financial markets and of being small enough so that anonimity does not exist within the village. At the same time, however, information about idiosyncratic shocks could be difficult to convey to the outside world. In other words, these societies might have limited enforcement capability. The lack of developed financial markets prevents the members of these societies from borrowing and lending and from insuring both among themselves and with the outside world. The fact that within the economy (or smaller subsets of agents) information problems are negligible, while enforceability problems might be serious, suggests the modelling framework to use when thinking of what type of institutions may develop to substitute the missing markets. In short, the only type of arrangement that may be possible are self enforcing contracts, this is, contracts thar are sustained by the mutual interest of the parties of mantaining the relationship.

In this paper we discuss three related issued that pertain to the extent to which what we define as island or village economies, which are just small isolated, poor agricultural societies, can smooth consumption. We start from the empirical implications of perfect insurance and discuss the empirical evidence that shows that consumption does fluctuates substantially, and more than what is implied by perfect insurance. However, the empirical work we describe also shows that despite large consumption fluctuations, income fluctuations are even larger, indicating the existence of some smoothing mechanism. The evidence points to non formal channels through which this insurance is carried out. In order to do the empirical assessment of consumption assessment in village economies we offer previously a brief overview of the implications of first best.

The second theme of this paper is the analysis of computable models that show the extent to which extended families can achieve insurance, sometimes total insurance, but usually partial insurance. We focus on self-enforcing contracts and document the implications of various characteristics of the environment in shaping the amount of possible insurance that can be implemented within the extended family. In particular we consider the effects of both preferences and income processes for the amount of risk sharing that can be sustained in equilibrium. We also discuss the empirical implications of this class of models and the scant empirical evidence on them.

The third theme of the paper is normative in nature. We are interested in understanding the extent to which policy can help in increasing the welfare of the members of village societies. Specificly, we have in mind institutions (henceforth called World Banks) that can partially observe the realizations of the shocks that affect income (what we call the aggregate part, the part that is common to all villagers) and that can compulsorily provide insurance against this fluctuations. This in principle sounds a good idea if only because the villagers do not have access to this type of insurance in the open market. What we find particularly interesting is that this type of policy has a deep influence over the type of enforceable arrangements, the social fabric, that the villagers can make upon themselves. First, we show examples where the well intentioned policy of the World Bank may induce a reduction of welfare. The reason for this apparent surprise could be thought of as a special case of Hart's standard result that opening markets but staying shy of complete markets may reduce welfare. We think of an interpretation in terms of the destruction of the social fabric that ocurrs when the public policy starts: with certain forms of government insurance, the incentives for a private insurance scheme to battle the consequences of autarky are smaller. So much smaller that in certain circumstances may completely compensate for the direct good effect of the policy.

We then turn to what we think is the key issue, how to design policies that do not have the aforementioned problem. Moreover, can we construct policies with the property that they strength the social fabric of self enforcing contracts rather than cripple it? Even more, can we do in a simple way that can actually be carried out by a middle of the road public institution? While we think that the first objectives are relatively self evident, the last one requires some comments. The reader has probably noted the similarity of the language with that of the literature in implementation theory. However, while we use some ideas and tools of implemention theory, our focus is quite different. The implementation literature provides a number of theoretical results that are often quite abstract. Moreover, specific outcomes are often implementable only through very complex and sometimes esoteric mechanisms that we see unfit for de facto implementation by a bureaucratic agency. We place the emphasis not in proving the implementability of the first best with some mechanism, but in achieving relatively good outcomes with very simple mechanisms.

In studying the properties of simple mechanisms, we use ours and, very often, our colleagues intuition for what could work. But the ulimate judge of the goodness of a policy/mechanism is the actual set of equilibria associated to it. To find them we use computational methods. Computing the equilibria rather than characterizing them, allows us to say many things about a small class of economies rather than a few things about a larger set of economies. This means that ultimately to know how good is the performance of a specific policy we have to go to the details of the environment where the policy is put in place.

One problem we face in the construction of simple mechanisms is that often the equilibrium one would like is not necessarily unique. This problem arises from the fact that the government can only manipulate aggregate payments and that the 'punisher' does not necessarily have a strong incentive to deprive the other agent of the aggregate payment, as this would not affect his utility. To circumvent this problem we try to construct mechanisms in which, off the equilibrium, an agent has strong incentives to implement the punishment.

2 The perfect insurance case: theoretical and empirical implications

In what follows, we will be considering economies in which individuals can enter contracts to diversify idiosyncratic risk and therefore smooth consumption. Individuals within these economies belong to what we call extended families, whose existence and membership is exogenously given. We start our discussion illustrating the theoretical and empirical implications of a model where first best can be achieved. By first best we mean, however, the first best allocation within the members of the extended family. We will not consider the possibility that members of the extended family share risk with people outside it and/or that new extended families are formed. A possible justification of this assumption is that the absence of information among members of different families prevents intertemporal trade among them completely. Obviously this is a simplification. While we will be working with extended families made of two individuals, the size of the family is not particularly important. Therefore, if one thinks of the family being as large as the village, one can get the standard first best results analysed in the literature.

The model we present in this section will be useful to provide a benchmark and to introduce notation. We will be considering simple cases, namely endowment economies, possibly without storage possibilities. While many of the results can be generalized to more complex situations, we find it useful, for explanatory reasons, to discuss the main ideas using a simple model. We will be discussing along the way which extensions to more realistic and complex settings are likely to affect our results.[1]

In addition to the introduction of the model, we also discuss its empirical implications and the main empirical findings available in the literature. As we document substantial deviations from first best allocations in village economies, this part constitutes a motivation for considering models where the first best is not achieved for very specific reasons.

2.1 The basic model

Consider an exchange economy populated by many individuals. These individuals receive endowments that are functions of idiosyncratic and aggregate shocks. Within the economy there exist extended families, exogenously determined and of fixed size. What identifies the families is the fact that members of the family have perfect information about each other idiosyncratic shocks. However, we should note that the size of what we call extended family can easily be enlarged. For simplicity we assume that extended families are made of two individuals.

Let z denote the aggregate shock with finite support in Z. This shock is common to all individuals in the economy. Furthermore, the shock z is Markov with transition matrix $\Gamma_{z,z'} = \text{Prob}(z_{t+1} = z'|z_t = z)$, and stationary distribution γ^*_z.[2] Let $s \in S$ denote the idiosyncratic or inidividual shock, which is also Markov, and is specific to each household. s may be multi-valued, so that it can incorporate both temporary and permanent elements and also has finite support. Conditional on two consecutive realizations of the aggregate shock,[3] we write the stochastic process for s as having transition $\Gamma_{s,z,z',s'} = \text{Prob}(s_{t+1} = s'|z_{t+1} = z', z_t = z, s_t = s)$, and unconditional means $\bar{z}$ and $\bar{s}$. In each state $\{z, s\}$ agents get endowment $e(z, s)$. We write compactly $\epsilon \equiv \{z, s\}$ and its transition $\Gamma_{\epsilon,\epsilon,'}$. We use the compact notation $y = (z, s_1, s_2)$ and we refer to its components as $\{z(y), s_1(y), s_2(y)\}$, which are the aggregate shock, and the idiosyncratic shock of agents 1 and 2 respectively. We also write compactly the transition matrix of the pair as $\Gamma_{y,y'}$. We denote by $\gamma^*(y)$ the stationary distribution of the shocks.[4] Moreover, the history of shocks up to t, is denoted by $y^t = \{y_0, y_1, \cdots, y_t\}$. We use $\pi(y^t|y_{-1})$ to denote the probability of history y^t conditional on the initial state of the economy y_{-1}.

[1] The model we use is based on Attanasio and Ríos-Rull (2000a).

[2] There are simple conditions that we assume and that guarantee that the stationary distribution exists, is unique and is the limit for any initial condition.

[3] See Castañeda, Díaz-Giménez, and Ríos-Rull (1998a) for details about the modelization of joint aggregate and idiosyncratic shocks.

[4] We make sufficient assumptions on the $\Gamma' s$ to ensure that there is a unique stationary distribution and no cyclically moving subsets.

In the absence of enforceability (and information) problems, the members of the extended family can share risk and achieve a welfare improvement, if utility functions are concave. The characterization of the allocation of resources under this sort of arrangement can be described by looking at a central planner problem. This was done by Townsend (1994). In particular, with two members in the extended family, the planner's problem maximizes a weighted sum of utilities subject to resource constraints. That is, for non negative weight λ_1, with $\lambda_2 = 1 - \lambda_1$, the planner chooses an allocation $\{c_1(y^t), c_2(y^t)\}$ for all y^t to solve

$$\max_{\{c_i(y^t)\}} \lambda_1 \sum_{t=0}^{\infty} \sum_{y^t} \beta^t \pi(y^t) u[c_1(y^t)] + \lambda_2 \sum_{t=0}^{\infty} \sum_{y^t} \beta^t \pi(y^t) u[c_2(y^t)] \tag{1}$$

subject to the resource constraints

$$c_1(y^t) + c_2(y^t) = e_1(y^t) + e_2(y^t) \tag{2}$$

The solution to this problem has to satisfy the following condition

$$u'[c_i(y^t)]\lambda_i = \xi(y^t) \tag{3}$$

where $\xi(y^t)$ is the Lagrange multiplier of the resource constraint after history y^t. This condition can be rewritten as

$$\frac{u'[c_1(y)]}{u'[c_2(y)]} = \frac{\lambda_2}{\lambda_1} \tag{4}$$

Equation (4) poses a very strong restriction on the equilibrium allocations: the ratio of marginal utilities is constant across all periods and state of nature, which allows us to drop the whole history as arguments of the consumption choices: only the current state y affects the consumption allocation. This is true for all possible weights that the planner may be using. This property is the one that we will like to find in the data as evidence of the agents being able to insure against shocks.

There is another important property in the characterization of the allocations provided by the planner problem: that theory by itself does not predict which specific allocation will ocurr. In large economies, where competitive equilibrium is a good representation of agents' interactions, there are strong additional restrictions on which set of weights are associated with the allocations that are picked. Essentially, there is generically at most a finite number of allocations that can be implemented as competitive equilibria without transfers. However, in families, or more in general in economies with a small number of agents, we do not know how the agents will share the gains from trade.

2.2 Empirical implications and evidence

Equation 3 has been stressed in a seminal paper by Townsend (1994), after which the implications of full risk sharing have been studied by several authors. Townsend (1994) proposed to test the hypothesis that changes in individual (log) consumption, after controlling for changes in aggregate consumption, are not correlated with changes in the level of resources available to an individual. The idea is that (log) consumption can be taken to approximate the (log) of marginal utility whose change should only reflect changes in the resource constraint multiplier in the central planner problem. This can be seen taking time differences of the log of equation 3: the differencing eliminates the unobserved Pareto weight.

Townsend (1994) tested this important implication of first best allocation using the ICRSTAT data from semi-arid India, with mixed empirical results. Mace (1991) andCochrane (1991) implemented similar tests on US data. In particular, Mace (1991) used Consumer Expenditure Survey data, while Cochrane (1991) used PSID data. Hayashi, Altonji, and Kotlikoff (1993) also used PSID data to test insurance both across and within families. Overall, the evidence suggest considerable rejections of the perfect insurance of aggregate shocks. Attanasio and Davis (1996) use grouped (by year of birth cohort and education) consumption data from the CEX together with wage data from the CPS and find strong rejections of the null, especially when considering low frequency changes.

An alternative test of the null has recently been proposed by Attanasio, Blundell, and Preston (2000) who look at the variance of log consumption within certain groups. This test is based on the idea that the variances of the marginal utility of consumption should be constant over time in a group that insures idiosyncratic shocks of its members, as it should reflect only the variance of the Pareto weights. This can be seen clearly from equation (4) . There are two advantages to this test. First, by considering the within group variance one can test insurance *within* a group, while the group means used by Attanasio and Davis (1996) tested for insurance of shocks across groups. Second, by changing the definition of groups one can focus on different types of shocks that can be economically meaningful. Attanasio, Blundell, and Preston (2000) find much stronger rejections of the null for broadly defined groups, such as those defined only by year of birth cohorts, than for groups defined by cohort and education.

The evidence both in Attanasio and Davis (1996) and in Attanasio, Blundell, and Preston (2000) is consistent with the hypothesis that transitory, high frequency shocks are somehow smoothed out, while more permanent relative shocks are reflected in changes in relative consumption. The idea that permanent components are more difficult to smooth out is consistent both with the idea that consumers can only save to smooth out shocks, and with the fact that permanent shocks are more difficult to share in the presence of imperfect enforceability.

An important point to notice is that of the power of the tests of perfect insurance. This issue is particularly relevant when the estimates of the coefficients used to test the null are likely to be affected by attenuation bias because of measurement error. Some of the results Mace (1991) obtained, which indicated a non rejection of the null, might be a consequence of measurement error in income. Attanasio and Davis (1996) and Attanasio, Blundell, and Preston (2000) try to get around this problem by grouping and instrumenting. However, the difficulty in constructing a suitable instrument might explain some of the high-frequency results that Attanasio and Davis (1996) get. Indeed, distinguishing between transistory shocks that can be easily self insured and measurement error can be quite hard.[5]

With the exeption of Townsend (1994), the papers cited above, use data from developed countries. However, many other studies, after Townsend (1994) have looked at the implications of perfect insurance in developing countries. These include the studies by Ravallion (1997) and Atkenson and Ogaki (1998). Atkenson and Ogaki (1998), in particular, consider a Stone Geary utility function. More recently, Ogaki and Zhang (2000) have failed to reject the null of perfect insurance, once they allow for a surviving level of consumption.

It is interesting to note that most of these tests only look at consumption (and income) realizations, without necessarily requiring specific information on the instruments that people might use to smooth out idiosyncratic fluctuations. It has been suggested that in village economies characterised by limited storage capabilities, small information problems and repeated interactions among agents, insurance contracts and arrangements are extremely rare.[6] Instead, people enters what Platteau (1997) has defined as quasi-credit arrangements, which are in their nature quite similar to the type of contracts, halfway between credit and insurance, that we described above. Platteau and Abraham (1987) and Platteau (1997) extensive evidence in this respect from fisherman villages in Southern India

[5]A possibility is to use different data sources that report measures of the same variable. Attanasio, Blundell, and Preston (2000) use CPS wage to instrument CEX wages. If measurement error is the only problem, this procedure should provide a reliable solution to it.

[6]Besley (1995) provides an interesting survey of risk sharing institutions and credit arrangements in developing countries. Fafchamps (1998) provides an interesting survey of the available evidence on quasi-credit.

and Africa.To study risk sharing, therefore, it can be quite profitable to study, in addition to income and consumption allocation, the particular instruments that household use to (partly) insure income shocks, such as gifts, informal credit, transfers and so on, when data on these variables exist.[7]

In an important paper, Udry (1994) considers credit arrangements in Nigeria and shows that these arrangements are not consistent with the implications of full risk sharing . In particular, Udry (1994) finds that both the maturity and the effective interest rate on loans (which determine the terms of repayment) often depend on the shocks that affect the two parties of the contract. Not only does he find that borrowers affected by negative shocks pay back less, but also that lenders in the same situation, get paid back more! Udry (1994) also discusses and estimates models in which information flows between the partners are not perfect (but shocks are observed ex-post by a village authority) and some households rationally default on their loans in some state of the world, even though they are punished in this case by the village authority. [8] Udry (1994) estimates such a model using data on debts, repayments and defaults by maximum likelihood. The fact that there he has only one cross section, implies that he is forced to consider a two period model and cannot consider explicitly the dynamic effects induced by imperfect enforceability in a repeated context. However, estimating a model of bilateral loan contracting that also considers the possibility of default, he finds that 'borrowers and lenders are engaged in risk pooloing through state-contingent loan repayments'. Such schemes bear remarkable similarities to the model we discuss.

Fafchamps (2000) discusses the importance of informal transfers and gifts in risk sharing agreements in rural Philippines. As Udry (1994), he sets his empirical analysis as a test of the perfect insurance hypothesis and mentions explicitly imperfect enforceability and imperfect information as a possible explanation of the rejections of the null. Interestingly, Fafchamps (2000) has information on 'network' membership and can test efficient risk sharing not just at the village level but at the network level.

Interestingly, both Udry (1994) and Fafchamps (2000) do not use information on consumption, like in many of the perfect insurance tests mentioned above. Instead, in addition to the information on income shocks, they use data on the instruments used for consumption smoothing: (informal) credit in the case of Udry (1994) and transfers and gifts in the

[7]In a recent paper, Dercon and Krishnan (1999) test first best allocation of resources within a households. Using data from rural Ethiopia they marginally reject efficient risk sharing among husband and wifes. Interestingly they also estimate the Pareto weights implied by their data and relate them to observable characteristics that might proxy for the bargaining power in the marriage.

[8]Moreover, Udry (1994) assumes that there are some transaction costs in loans, so that there is a positive mass at zero loans.

case of Fafchamps (2000).

3 The failure of perfect insurance

As often the implications of perfect insurance are empirically rejected, we move on to the discussion of models where the failure of perfect insurance is modelled explicitly. We start our discussion with a brief mention of models with imperfect information. However, the focus of this section and of our paper is on models where perfect insurance fails because of imperfect enforceability of contracts. We believe that these models are particularly suitable to analyse situations in which there are limited storage capabilities (therefore reducing the possibility of self insurance) and in which information about idiosyncratic shocks is reasonably public within the village. On the other hand, it might be difficult to convey this type of information to the external world and therefore enforce punishemnts for deviations from pre-established contracts. This information structure is important for the construction of optimal aggregate insurance schemes that we discuss in Section 6.

The extent to which the models we discuss are relevant from a policy perspective is largely an empirical question. It is therefore important to focus on the implications of the models we will be considering and to discuss the available empirical evidence. For this reason, we conclude the section with a discussion of the empirical evidence on models with imperfect enforceability.

3.1 Imperfect information

There is a large body of work that attempts to understand what can be done when first best is not implementable. This work includes work by Atkeson and Lucas (1992), among many others that studies the implementable allocations when the current shock of agents (which can be either an income or a preference shock) is unobservable.[9] In many cases, it turns out that the optimal allocation is characterized by ever increasing inequality.

In a very recent and nice paper, Cole and Kocherlakota (1997), have shown that when storage is both feasible for the agents and unobservable by third parties, the optimal implementable allocations are essentially those can be achieved by agents holding an asset,

[9] Other relevant papers include Phelan and Townsend (1991), Green (1987), Wang and Williamson (1995).

perhaps in negative quantitative, that has a rate of return that is not state contingent. In this sense Cole and Kocherlakota (1997) has provided an important link between the literature that studies constrained optimal allocations and another literature that is interested in the properties of allocations and prices when the market structure is incomplete. Models with only one asset and with numerous agents differing in income and wealth have been used to address various questions in macroeconomics (Aiyagari (1994), Huggett (1993) , Krusell and Smith (1998), Castañeda, Díaz-Giménez, and Ríos-Rull (1998a) , Castañeda, Díaz-Giménez, and Ríos-Rull (1998b)). Models of this type and more than one asset yet still incomplete markets have been used in finance to look for solutions to the equity premium puzzle (Krusell and Smith (1997) with a large number of agents, and Heaton and Lucas (1992), Marcet and Singleton (1990), Telmer (1992) in economies with few agents).

We think that obervability issues are inherently related to the anonimity of large societies, and that for small agricultural economies it is more useful to organize our thinking around the problem of enforceability. This is especially true if we are interested in economies where the members have difficulties storing assets. Accordingly, in the rest of the paper we consider economies where agents cannot store goods or hold assets and where there are enforceability but not observabilily problems.

3.2 Imperfect enforceability

In this section, we consider environements where there is not access to a technology to enforce contracts, which may preclude agents to achieve the first best allocations. We want to think of this as a situation where agents cannot convey information about shocks in an easily verifiable way to the outside world. In such a situation, agents are likely to enter only contracts that are self-enforceable. In particular, we are going to look at allocations that can be achieved within a repeated game where there is a threat to reverse to the worst possible subgame perfect equilibrium. This is what we call the 'autarky' equilibrium, that is one in which each member of the extended family consumes her idiosyncratic endowment. This approach arises from the work of Abreu (1988) and Abreu, Pearce, and Stacchetti (1990) and has been used by most papers in the literature. The list of papers that have looked at problems like this (which are essentially consumption smoothing problems) include Thomas and Worrall (1990), Ligon, Thomas, and Worrall (1997), Ligon, Thomas, and Worrall (1998), Alvarez and Jermann (1998), and Kocherlakota (1996).[10] Kehoe and Levine (1993) has looked at this problem as it relates to access to markets.

[10]Coate and Ravallion (1993) were among the first to consider self-enforcing contracts. However, they restrict themselves to static contracts that are not necessarily optimal.

We look at allocations that are accepted voluntarily by agents that in every period and state of nature have the option of reverting to autarky.[11] Therefore, if we denote with $\Omega(\epsilon)$ the value of autarky, our assumptions on the endowments processes imply that it can be written as:

$$\Omega(\epsilon) = u\left[e(\epsilon)\right] + \sum_{\epsilon'} \; \Gamma_{\epsilon,\epsilon'} \;\; \Omega(\epsilon'). \tag{5}$$

Given this, the enforceability constraints that we will have to consider are given by the following expression:

$$\sum_{r=t}^{\infty} \sum_{y^r} \;\; \beta^{r-t} \;\; \pi(y^r|y^t) \;\; u[c_i(y^r)] \;\; \geq \;\; \Omega[\epsilon(y_t)]. \tag{6}$$

3.2.1 A recursive formulation

These constraints (one for each of the two agents) can be used to change the central planner problem. Adding these two constraints to the maximization problem above, changes the nature of the problem considerably. In particular, the problem becomes, as it is written, non-recursive. We follow Marcet and Marimon (1992) and Marcet and Marimon (1995) and re-write the planner problem to make it recursive (see also, Kehoe and Perri (1997)). In particular, we can write the Lagrangian for such a problem as

$$\sum_{t=0}^{\infty} \sum_{y^t} \beta^t \; \pi(y^t) \; \left\{ \sum_{i=1}^{2} \; \lambda_i \; u[c_i(y^t)] + \right.$$
$$\left. \sum_{i} \mu_i(y^t) \left[\sum_{r=t}^{\infty} \sum_{y^r} \beta^{r-t} \pi(y^r|y^t) u[c_i(y^r)] - \Omega_i[\epsilon(y_t)] \right] \right\} \tag{7}$$

plus the standard terms that relate to the resource constraints. The μ_i are the multiplier associated to the participation constraints. Noting that $\pi(y^r|y^t)$ can be rewritten as $\pi(y^r) =$

[11] As Ligon, Thomas, and Worrall (1998) do, we could also subtract from the value of autarky any punishment that can conceivably be imposed on an individual that deviates from the pre-agreed contract. As we do not use these punishments below, we do not consider them in the equation below to avoid clustering the notation.

$\pi(y^r|y^t)\pi(y^t)$ we can rewrite the Lagrangian as

$$\sum_{t=0}^{\infty}\sum_{y^t}\sum_{i}\beta^t\ \pi(y^t)\ \left\{M_i(y^{t-1})u[c_i(y^t)] + \mu_i(y^t)\left[u[c_i(y^t)] - \Omega_i[\epsilon(y_t)]\right]\right\} \tag{8}$$

plus again the terms that refer to the feasibility constraint. The newly introduced variable, $M_i(y^{t-1})$ is defined recursively as $M_i(y_{-1}) = \lambda_i$ and

$$M_i(y^t) = M_i(y^{t-1}) + \mu_i(y^t) \tag{9}$$

Note that at time t , the $M_i(y^t)$'s are equal to the original weights plus the cumulative sum of the Lagrange multipliers on the enforcement constraint at all periods from 1 to t. The first order conditions that can be derived from this modified Lagrangian include

$$\frac{u'\left[c_1(y^t)\right]}{u'[c_2(y^t)]} = \frac{M_2(y^{t-1}) + \mu_2(y^t)}{M_1(y^{t-1}) + \mu_1(y^t)}, \tag{10}$$

in addition to the complementary slackness conditions. The next step consists in renormalizing the enforceability multipliers by defining

$$\varphi_i(y^t) = \frac{\mu_i(y^t)}{M_i(y^t)} \quad \text{and} \quad x(y^t) = \frac{M_2(y^t)}{M_1(y^t)} \tag{11}$$

The virtue of this normalization is that it allows us to keep track only of the relative weight x. Its transition law can be written as

$$x(y^t) = \frac{[1-\varphi_1(y^t)]}{[1-\varphi_2(y^t)]}\ x(y^{t-1}) \tag{12}$$

by noting that $[1-\varphi_1(y^t)]\,M(y^t) = M(y^{t-1})$.

We are now in a position to write this problem recursively. To do so we define a mapping **T** from values into values, a fixed point of which are the value functions that characterize the solution to our problem. To solve our model numerically, as we do in the next section, we actually follow this procedure, that is, we iterate from a certain initial set of value functions. Successive approximation have yielded in every case the desired fixed point.

The state variables are the current value of the shock y (recall that, due to the fact that the shocks are Markov, their current value is sufficient to evaluate conditional expectations) and the current value of the relative weights x. Let $\mathbf{V} = \{V_0(y,x), V_1(y,x), V_2(y,x)\}$ be three functions one for the planner and one for each of the agents, that satisfy the following property:

$$V_0(y,x) = V_1(y,x) + \ x \ \ V_2(y,x) \tag{13}$$

The mapping $\mathbf{T}$, whose fixed point we are looking for, updates these three functions, and, therefore, we write the updated functions as

$\mathbf{T}(\mathbf{V}) = \{T_0(\ \mathbf{V}), T_1(\mathbf{V}), T_2(\mathbf{V})\}$.

To define $\mathbf{T}$, we first solve the following auxiliary problem where no incentive constraints are taken into account

$$\Phi(y,x;\mathbf{V}) = \max_{c_1,c_2} \ u(c_1) + x \ u(c_2) + \beta \ \sum_{y'} \Gamma_{y,y'} \ V_0(y',x) \tag{14}$$

subject to the feasibility constraint (2), with solution $c_i^{\Phi,\mathbf{V}}$. Note that in this problem the relative weight x is constant. Next, we verify the enforceability of the solution to (14). This means verifying whether

$$u[c_i^{\Phi,\mathbf{V}}(y,x)] \ + \ \beta \ \sum_{y'} \ \Gamma_{y,y'} \ V_i(y',x) \geq \Omega[\epsilon(y)] \quad \text{for} \quad i = 1,2 \tag{15}$$

If (15) is satisfied, then $T_0(\mathbf{V}) = \Phi(y,x; \ \ \mathbf{V})$, and $T_1(\mathbf{V})$ and $T_2(\mathbf{V})$ are given by its left hand side. It is easy to see that (15) cannot be violated for both agents at the same time (just note that autarky is a feasible allocation). The only remaining problem is to update the value functions when the constraint is binding for one of the agents, say agent 1. In this case, we solve the following system of equations in $\{c_1, c_2, x'\}$.

$$\Omega[\epsilon(y)] \ = \ u(c_1) \ + \ \beta \ \sum_{y'} \ \Gamma_{y,y'} \ V_1(y',x') \tag{16}$$

$$x' \ = \ \frac{u'(c_1)}{u'(c_2)} \tag{17}$$

$$c_1 + c_2 \ = \ e_1(y) + e_2(y) + 2\tau(y) \tag{18}$$

With solution $\{\bar{c}_1, \bar{c}_2, \bar{x}'\}$. [12] To update the value functions we let

$$T_1(\mathbf{V})(y,x) = u(\bar{c}_1) + \beta \sum_{y'} \Gamma_{y,y'} \; V_1(y', \bar{x}') \tag{19}$$

$$T_2(\mathbf{V})(y,x) = u(\bar{c}_2) + \beta \sum_{y'} \Gamma_{y,y'} \; V_2(y', \bar{x}') \tag{20}$$

$$T_0(\mathbf{V})(y,x) = T_1(\mathbf{V})(y,x) + \; x \; T_2(\mathbf{V})(y,x) \tag{21}$$

A fixed point of $\mathbf{T}$, *i.e.* a $\mathbf{V}^* = \mathbf{T}(\mathbf{V}^*)$, gives the value to the problem of maximizing a weighted sum of utilities. Moreover, it also gives us a way to completely characterize the properties of such a solution by numerical methods. This means that for any parameterization we can tell whether the enforceable allocation is autarky, the first best or anything in between. We can also study how the enforceable allocations are affected by changes in the environment.

Note how different this type of problem is from a standard optimization problem. Note that there is more than one relevant set of first order conditions: binding states are represented by alternative Euler equations characterized by the default constraints.

3.2.2 Alternative solution methods

In the literature, alternative solution methods have also been proposed. Following the original Thomas and Worrall (1988), Ligon, Thomas, and Worrall (1997), and Ligon, Thomas, and Worrall (1998) characterize the present model by considering the set of Pareto efficient allocation that also satisfy the participation constraints. This procedure leads them to characterize the solution to the problem in terms of a set of state dependent intervals for the ratio of marginal utilities. The evolution of the ratio of marginal utilities is then described as follows. If the ratio of marginal utilities of consumption at time t follows within the interval of the state that occurrs at date t', the ratio of marginal utilities is kept constant. If, on the other hand the existing ratio of marginal utilities follows outside the interval, the program adjusts consumption so to move the ratio of current marginal utilities within the intervales, but moving it by the smallest amount.

Ligon, Thomas, and Worrall (1997) stresses how such a method highlights the fact that self-enforcing insurance contracts are midway between credit and insurance, a concept that is also stressed by Platteau (1997). Suppose, for instance, to start from a situation where

[12] There will typically be only one solution given the monotonicity of all the functions involved.

the ratio of marginal utilities is one. In such a situation, first best would imply a simple sharing of the total output. Suppose now thta individual 1 is relatively luckier and that, corresponding to that particular state of the world, the current ratio of marginal utilities follows outside from the relevant interval. This meas that individual one is 'constrained'. The program implies that the transfer individual one makes is smaller than first best and moves the ratio of marginal utilities to the limit of the interval for that particular state, in this case, the relative weights in the planner function will move in favour of the individual one. If in the following period the shock is the same for the two individuals (and the ratio of marginal utility falls within the relevant interval) the ratio of marginal utilities will be kept constant. This implies transfers from individual two to individual one. Notice that in first best these transfers would be equal to zero. What is happening is that individual 2 is paying back individual 1 for her previous tranfser. When a new state of the world throws the marginal utility outside the relevant interval, the analogy with a credit contract ends. Indeed, the previous story is erased completely and the insurance aspect of the contract becomes more apparent.

There has been an attempt to use the mathematical apparatus developed by Abreu, Pearce, and Stacchetti (1990) with the value sets as arguments of the operators that they define directly as a means of computing equilibria. This is computationally very demanding since it requires to iterates in value sets (actually convex sets), something that is very hard to do. Examples of this work are Judd and Conklin (1993) and Phelan and Stacchetti (1999). These two papers use different algorithms to store sets, and the methods that they have developed have not been used by other researchers.

Alvarez and Jermann (1998) have a very interesting and useful way to characterize aggregate growth and aggregate uncertainty in models with imperfect enforceability. They show that to consider these phenomena it is sufficient to redifine the discount factor (and make it state and time dependent in a particular way). Moreover, they present calibrations that show that the possibility of default makes asset pricing more similar to observed data. In particular, Alvarez and Jermann (1998) go some way towards explaining the equity premium puzzle and the low values of real interest rates on safe assets. Alvarez and Jermann (1998) stresses the similarities between their approach and the recent study of Luttmer (1999).[13]

[13] Alvarez and Jermann (1998), uses a yet different characterization of this type of model. As they are interested in the asset pricing implications of this type of models, they consider contingent loans. The lack of enforceability is then reflected in the impossibility, for individuals affected by negatve shocks, to borrow more than an amount that they would have no incentives to default over in any state of the world next period. While the characterization of the equilibrium is somewhat different, clearly the results Alvarez and Jerman get are very similar.

3.2.3 Extensions and complications

The simple model we present above can be extended and complicated in a variety of directions. First one can consider many households, rather than only two. Results with many households are presented by Ligon, Thomas, and Worrall (1997), and Ligon, Thomas, and Worrall (1998) and by Alvarez and Jermann (1998). The analysis does not present any conceptual difficulty. The central planner problem will have to be modified to consider the participation constraints of all the households involved. In terms of the Ligon, Thomas, and Worrall (1998), approach, one has to consider a multidimensonal Pareto frontier.

A more complex extension is the consideration of storage possibilities. Storage is difficult for several reasons. First, the solution of the problem has to determine where the investment takes place. When the rate of return is independent of the size of the investment the solution of the first best is that it is irrelevant where the investment takes place. When contracts have to be self enforceable the location of the investment affects the conditions in which each agent reverts to autarky, posing an additional margin to induce participation in the scheme that has to be taken into account. This problem is avoided by Ligon, Thomas, and Worrall (1998) by modelling a technology where the process of reversion to autarky involves the loss of assets while being in autarky is compatible with savings. They defend this assumption on the basis that the possibility that storage is, in any case, a communal thing (maybe administred by a local authority). In this case, deviants will not have the possibility of storing under autarky. Second, the presence of storage introduce non-convexities into the problem that make the numerical solution of the problem particularly complex.

In a recent paper, Lambertini (1999) considers a three period overlapping generation model with limited enforceability. In such a model, one has to assume the presence of storage possibilities. At least three periods are necessary, otherwise no contract could ever be enforced. Moreover, autarky is defined as a situation in which people not only cannot borrow, but are also prohibited from saving (in that their saving can be appropriated). This framework allows Lambertini to consider the effects of limited enforceability in a finite lives context. In particular, Lambertini shows that if the income profile is hump-shaped, the equilibrium generate borrowing constraints for young individuals that prevent consumption smoothing. In the absence of commitment, the model, in general, has multiple equilibria.

Kehoe and Levine (1993), and Levine and Kehoe (2000) also consider models with limited commitment. In it agents cannot borrow as much as they could with perfect commitment because there is always the possibility of bankruptcy. This induces an endogenous borrowing limit.

3.3 Empirical evidence

While many papers have looked at the determinants of private transfers and at their interaction with public transfers (see below), the evidence on imperfect enforceable models is limited. Only a handful of papers has taken the models we discussed above to the data in order to test their implications. We start by reviewing some evidence on the crowding out of private transfers by public transfers. We then consider the little empirical evidence on models with imperfect enforceability and conclude with possible extensions.

3.3.1 Transfers and crowding out

Several papers have analysed private transfers among families and how these interact with the provision of public transfer programs. Obviously, models with imperfect enforceability are not necessarily the only ones that can be used to analyze the interaction between private and public ones, especially if the latter do not have an insurance component. It is possible, for instance, that transfers are motivated by altruism.[14] In such a framework, public transfers will certainly crowd out private transfers, under standard assumptions on preferences. More generally, it is possible what we measure as transfers is given in exchange for some sort of service. For instance, children might transfer resources to parents in exchange for help with small kids or parents might be transfering resources to children in exchange for support and care. Indeed, the model we discussed above is a particular kind of exhange as current transfers are given in order to receive future transfers. While in the model we consider, in which the effect of public transfers works through a reduction of the variance of aggregate shocks, the effect of public transfers is unambiguously negative, there are other situations in which such effect can be ambiguous. Examples of these situations are given in Cox (1987b).

Several studies have analysed the extent to which public transfers of different nature, ranging from social security and pensions to food aid, crowd out private transfers. Cox and Jakubson (1995) analyse US data on AFDC, while Cox, Eser, and Jimenez (1998) look at whether private income transfers are affected by public transfers in Peru.[15] Jensen (1999) analyses the relationship between migrant remittances and the possible recipients of old age pension in South Africa. In most of these studies the hypothesis that private transfers are crowded out by public ones is tested by means of simple regressions where the dependent variables are private (net or gross) transfers or remittances and the independent

[14] See Cox (1987a).

[15] In particular, Cox, Eser, and Jimenez (1998) find that public transfers have a positive effect on the amount of private transfers but that 'social security benefits crowds out the incidence of private transfers'.

variables include, in addition to standard controls, some indicators of whether the household receives some form of public transfers (for instance public pensions). Some studies look at the intensive margin, while others consider the extensive margin or both. Typically either probit or tobit models are used, even though recently some researchers have tried also non-parameteric methods.[16]

In addition to the non-linearity of models where the dependent variables is discrete or truncated, the main problem faced by empirical researchers in this area is that of endogeneity. Typically, the beneficiaries of public transfer schemes are not chosen randomly creating, in all likelihood, an important endogeneity problem. It is therefore particularly valuable to consider the effect that public transfers have on private transfers when there is a good 'instrumental' variable available. Albarran and Attanasio (2000) expand the simple exercise performed in Attanasio and Ríos-Rull (2000a) and consider the effect that a large public transfer program, called Progresa, has had in rural Mexico. The Mexican data set is particularly attractive because, when the program was started, it was decided to evaluate it. For such a purpose, a number of villages were randomized out of the program for two years. One can therefore compare beneficiaries in the treatment villages and would-be beneficiaries in the control villages.

The results obtained in Albarran and Attanasio (2000) indicate a substantial amount of crowding out. Such a result holds both when looking at a probit for any kind of transfer (monetary or in kind) or at a Tobit for monetary transfers.

As we discuss in section 4, a transfer that moves the mean of the endowment causes a decrease in the level of private transfers. The results Albarran and Attanasio (2000) obtain, therefore, are consistent with the implications of the model with imperfect enforceability.

3.3.2 Evidence on models with imperfect enforceability

To the best of our knowledge, the only two papers with direct evidence on these models are by Foster and Rosenzweig (1999), and Ligon, Thomas, and Worrall (1998). In addition, Attanasio and Ríos-Rull (2000a) have interpreted some of the evidence from the Progresa program in Mexico as relevant for the importance of the incentives created by imperfect enforceability. Krueger and Perri (1999) have interpreted some US evidence on consumption and income inequality as consistent with the type of models we discussed. Alvarez and Jermann (1998) have provided some calibration in favor of these models. Finally, Platteau

[16]See, for instance, Jensen (1999). The use of non-parametric methods to estimate truncated models implies some serious identification problems. In particular, identification requires that one finds a variable that affects the extensive margin (whether the household receives a transfer or not) that does not affect the quantity of transfer received. This is obviously a difficult problem.

and Abraham (1987) explicitly refer to models with imperfect enforceability to explain their evidence, while Udry (1994) and Fafchamps (2000) evidence is consistent with these models.

Foster and Rosenzweig (1999) is the only paper that uses evidence on transfers to assess the relevance of the models we have been discussing. Moreover, they extend the model to incorporate an altruistic motive in individual preferences. Rather than estimating a full structural model, Foster and Rosenzweig (1999) notice that the absence of perfect enforceability and endogenous missing market has specific implications for the time series properties of transfers. In particular, they notice that, conditional on current shocks, current transfers should be negatively related to the cumulative amount of past transfers. First differencing such an equation, they obtain a relationship that can be estimated in panel data. In particular, they obtain that the change in transfers should be inversely related to the lagged level of transfers, once one conditions on shocks. Given that it is difficult to obtain a closed form solution for transfers in such a model, to have an idea of what a plausible coefficient of such a regression is, Foster and Rosenzweig run similar regressions on data generated by simulating a model like those we discussed. They find evidence that the regression coefficient obtained on simulated data is not too different from those obtained on actual data from Pakistan and India.

Ligon, Thomas, and Worrall (1998), instead, take a fully structural approach. They consider a model very much like the one we considered above and, by matching it to the ICRSTAT data (originally used by Townsend (1994) to test the implications of perfect insurance), they estimate the structural parameters of the model by maximum likelihood. The computation of the likelihood function is numerically very intensive as it involves computing, for each value of the parameters, the decision choices implied by the model. For this reason, Ligon, Thomas, and Worrall (1998) are forced to drastic simplifications. Even though their theoretical model can account for storage and for multiple agents among whom the insurance contracts are stipulated, in the empirical applications they assume that there is no storage and that each household plays a game with the rest of the village, rather than considering all the households at the same time. Even with these strong simplifications, Ligon, Thomas, and Worrall (1998) find that the model fits the data remarkably well and much better than both the perfect insurance model and the static model considered by Coate and Ravallion (1993). In particular, Ligon, Thomas, and Worrall (1998) show that the correlation between actual consumptions and consumption generated by the model is highest for the model with imperfect enforceability (over perfect insurance, autarky and the Coate and Ravallion (1993) model).

All the papers we mentioned are not exempt from criticism. The most crucial point is the fact that these models neglect to consider storage. As we discussed above, the possibility of storage is unlikely to affect the *qualitative* features of the equilibrium. However, storage affects directly the amount of risk sharing that can be sustained in equilibrium. Therefore an empirical exercise that neglects the possibility of storage might lead to results that are seriously biased, especially in situations in which storage is, at some level, an important way to smooth out idiosynctratic shocks.

3.3.3 Extensions

The existing papers are important first steps in the study of the implications of models with imperfect enforceability. However, there is still much work that needs to be done. In our opinion there are two particularly fruitful directions this research can take, even though the data requirements to implement these ideas can be quite formidable.

In his paper, Kocherlakota (1996) devotes the last section of his paper to the discussion of the empirical implications of models with imperfect enforceability. Kocherlakota stresses how the empirical implications of models with imperfect enforceability can be different from those of models with imperfect information. He notes that the model can be re-written as one in which the weights of the social planner problem change with the shocks received by the individual agents. As the weights that determine the allocation of resources are equal to the ratio of marginal utilities at the beginning of the period, a testable implication of the model is that conditional on the lagged ratio of marginal utilities, current consumption should not depend on any other lagged information. In private information situations, this is not necessarily the case. While this is an interesting result, Kocherlakota stresses that this is not a strong implication. The fact that the ratio of marginal utilities is a sufficient statistic for current consumption does not necessarily imply constrained efficiency of the resource allocation, which is what the models we consider imply.

However, Kocherlakota notices that for people that are unconstrained, in that their participation constraint is not binding, there is a standard Euler equation that governs the evolution of consumption. Moreover, only a subset of individuals in a village can be constrained in a certain period: that is the participation constraint cannot be binding for everybody. In addition, if we find an unconstrained individual, we can be sure that individuals with a higher marginal utility of consumption are also unconstrained. The model then has strong implications for constrained and unconstrained individuals. For the unconstrained, the ratio of marginal utilities will be constant and determine completely consumption. For the constrained, instead, own marginal utility will not be relevant for the determination of current consumption, which will instead be determined by the value of shocks and by the marginal utility of unconstrained individuals.

Kocherlakota's characterization of the implications of the model is a very interesting one. However, it is also clear that the data requirements this requires are quite formidable. One would want to use time series data covering a long enough period to warrant precise estimates. Notice that, as with the estimation of Euler equations for consumption, consistency requires 'long-T' asymptotics. Alternatively, one could use information about several villages if one is willing to assume that the shocks received by the villages are independent and that the villages are isolated .

Ligon, Thomas, and Worrall (1998) also consider the Euler equation that links the equilibrium evolution of consumption. This can be written as follows:

$$u_i'(c_s^i) = \beta(1+R)E_s[u_i'(c_r^i)] + \omega_i/\lambda_i + \beta E_s[\phi_r^i((1+R)u_i'(c_r^i) - f_r'^i)] \tag{22}$$

where β is the discount factor, R the fixed and exogenous return on the storage technology (that can be negative), λ_i is the initial Pareto weight in the social planner problem, ω_i is the multiplier on the constraint that storage cannot be negative, ϕ_i the multiplier on the participation constraint and f' represent the marginal effect of an additional unit of storage on the value of autarky. Ligon, Thomas, and Worrall (1998) provide a nice interpretation of equation 22. The first term represents the traditional effect that a reduction ion current consumption will translate, thorugh the storage technology and the discount factor in future utility. The second term also takes into account the effect that standard liquidity constraints have on comnsumption. The third effect captures the effect that an additional unit of saving has on the participation constraints. Whether this is positive or negative depends on which of the two effects in the square bracket prevails. The last term depends on the particular arrangements for storage. If storage is held comunnally it is zero. Notice that there might be some individuals for whom both ω_i and ϕ_i are equal to zero. These are individuals who are sufficiently 'lucky' so to wish to be saving, but not 'lucky enough' for their participation constraint to be binding. On the two sides of these individuals there are those for whom ϕ_i is positive and those for whom ω_i is positive. Note that both multipliers cannot be positive at the same time since agents will only be tempted to go to autarky when they have stored a sufficiently large amount of the good, not when they would like to move resources from the future to the present.

This type of equation has not been exploited so far. There are two types of difficulty. The first is common to the implementation of the tests proposed by Kocherlakota, that is the fact that the data requirements, especially in terms of the length of the period, can be prohibitieve. The other is the fact that the multipliers present in equation (22) are not observable. One possibility would be to parametrize the Kuhn- Tucker multipliers and relate them to past income shocks, as well as other observable characteristic.

4 Imperfect enforceability: characterizing equilibria

The aim of this section is to characterize the properties of the equilibria of the models with imperfect enforceability discussed above. In particular, we are interested in establishing the relationship between changes in various preference and technology parameters and the amount of risk sharing that can be sustained in equilibrium when contracts are not perfectly enforceable. For many of the parameters of the model analytical results are available. For instance, it is obvious that an increase in the discount factor β induces more risk sharing. In other cases, however, it is necessary to use numerical simulations to characterize the equilibria. And even when the effect of changes in the parameters of the model can be signed analytically, it is important to quantify these effects in various situations. It is for this that, while mentioning some analytical results, we will focus on the results of numerical simulations.

In the numerical simulations, given the parameters of the model, we solve for the consumpion functions in the environment described above and use them to simulate the model for 40,000 periods. We discard the first 100 hundred periods and compute the relevant statistics averaging across simulations. All the simulations are generated with the same initial seed, so that the realized sequence of shocks is the same for all economies.

The parameters of the various experiments we perform are presented in top panel of Table 1. These include the preference parameters (risk aversion and discount factor) and the parameters that characterize the endowment processes (points of support and transition matrices). In this part of the Table we also report the implied properties of the income processes, such as its mean, standard deviation and first order autocorrelation.

In the bottom panel of Table 1, we report the standard deviation and autocorrelation of consumption in the three types of equilibria (enforceable, first best and autarky). Finally, we report three statistics that are indicative of the amount of risk sharing that is achieved in the equilibrium with self enforceable contracts: the average level of private transfers as a percentage of per-capita income and as a percentage of the transfers in the first best equilibrium and, finally, the fraction of consumption cross sectional variance (after removing aggregate consumption) over the variance of endowments. Such a ratio should be zero if first best is achieved, and one under autarky.

We start our discussion by looking at a baseline specification, whose features are re-

Table 1: **Properties of Baseline and of Other Specifications**

	(1) Base line	(2) + β	(3) + γ	(4) + Id Per	(5) − Ag Var	(6) + Ag Per b	(7) + Ag Per g	(8) + Ag Inc
				Preference Parameters				
β	.85	**.88**	.85	.85	.85	.85	.85	.85
γ	1.1	1.1	**1.3**	1.1	1.1	1.1	1.1	1.1
				Idiosyncratic Shock Process				
Values	1,.1	1,.1	1,.1	1,.1	1,.1	1,.1	1,.1	1.,.1
$\Gamma_{g,g}, \Gamma_{b,b}$	[.7,.7]	[.7,.7]	[.7,.7]	[**.8,.8**]	[.7,.7]	[.7,.7]	[.7,.7]	[.7,.7]
				Aggregate Shock Process				
Values	1,.1	1,.1	1,.1	1,.1	**.98,.28**	**1.01,.21**	**.99,.01**	**1.2,.3**
$\Gamma_{g,g}, \Gamma_{b,b}$	[.9,.1]	[.9,.1]	[.9,.1]	[.9,.1]	[.9,.1]	[.9,**.3**]	[**.92**, .1]	[.9,.1]
				Output Statistics				
Aver	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.66
St.dev.	.52	.52	.52	.52	**.50**	.52	.52	.52
Autocorr	.29	.29	.29	**.44**	**.33**	**.35**	**.30**	.29
Aggr.	.00	.00	.00	.00	.00	.20	.01	.00
Idios.	.40	.40	.40	.40	.40	.40	.40	.40

Properties of the Allocations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Enforceable Consumption				
st. dev.	.45	.43	.44	.48	.43	.45	.44	.47
autocorr	.29	.27	.30	.43	.34	.37	.30	.30
				First Best Consumption				
st. dev.	.42	.42	.42	.42	.38	.42	.42	.42
autocorr	.23	.24	.24	.35	.28	.32	.25	.23
				Autarkic Consumption				
st. dev.	.52	.52	.52	.53	.50	.52	.52	.52
autocorr	.29	.29	.29	.44	.33	.35	.30	.30
				Average enforceable transfer as % of				
Income	.138	.148	.048	.077	.097	.119	.144	.065
1st best Tr	.905	.966	.952	.505	.627	.771	.936	.478
				Var. of Consumption / Var. of Endowments				
	.271	.139	.152	.537	.377	.310	.221	.490

ported in the first column of Table 1 . The discount factor is equal to .85, and the coefficient of relative risk aversion is equal to 1.1. Both aggregate and idiosyncratic shocks can take two values. Bad shocks are quite severe: the low value for both aggregate and idiosyncratic shocks is equal to 10% of the high value. The persistence properties of the two shocks, however, are quite different. Bad aggregate shocks are much rarer and less persistent than idiosyncratic shocks. Overall the first order autocorrelation of aggregate shocks is close to zero, while that of idiosyncratic shocks is about .4. The overall autocorrelation of per capita output is .29.

The utility achieved by self enforceable contracts is in between that under autarky and that under first best. In this particular example, the intertemporal allocation of resources is closer to first best than to autarky. This can be seen by looking at the ratio of the cross sectional variance of consumption to the cross sectional variance of endowments (last row of Table 1): the value of .27 is closer to 0 than to 1. The amount of risk sharing that happens is also reflected in the relatively high (absolute) value of private transfers, that on average, are equal to 14% of output (and 90% of the transfers that would occur in first best). Notice also that the standard deviation of consumption of the enforceable allocation is midway between the standard deviations of consumption in first best and in autarky. The autocorrelation of consumption under the incentive compatible equilibrium is not different from the autocorrelation that would be observed under autarky and substantially higher than that that one would observe under first best. Indeed it is possible to have cases in which the constrained efficient equilibrium generates more persistence in consumption than in autarky.

The relatively high persistence of consumption in the constrained efficient equilibrium is related to another interesting phenomenon. As we mention above, it is possible that in this equilibrium transfers are not only smaller but of the opposite sign than those that would be observed in the first best. Even in the simple example we propose here this does happen. For the parameters in the first column of Table 1, on average, the system finds itself 3.5% of the time in a situation in which private transfers flow form the relatively poorer to the relatively richer individual. This happens only when the aggregate state is good and the ratio of marginal utilities (the state variable in our recursive formulation) has reached a certain trigger level. This happens when one of the two individuals has been relatively 'lucky' for some periods so that her participation constraint has been binding repeatedly.

In columns (2) to (8) we change various parameters of the system. In particular, in column (2) and (3) we increase the values of the two preference parameters, while in column (4) to (8) we change the parameters of the endowment processes. The parameters that change relative to the baseline specification are in boldface in Table 1.

In column (2) we increase the rate of discount from .85 to .88. As expected, this has the effect of increasing risk sharing and bringing the constrained efficient equilibrium closer to first best and farther away from autarky. The same happens when we increase the coefficient of relative risk aversion, which is done in column (3). In this column the γ is changed from 1.1 to 1.3. Once again we see an increase in the amount of risk sharing. The ratio of the variance of consumption to the variance of endowments moves from .27 to .15, while the transfers as a fraction of first best transfers increase from .91 to .95. Notice that even though the changes in the parameter values are quite small, their effects are sizeable.

In column (4), we start looking at changes in the economic environment in which the agents live. First, we increase the persistence of idiosyncratic shocks. This has the unambiguous effect of reducing risk sharing, for reasons that should be, by now, obvious. An agent receiving a very persistent and positive shock will not want to share it (or will not want to share a persistent negative shock received by her partner).

In column (5), we decrease the variance of the aggregate shocks, leaving the mean (and the other income processes) unaffected. This exercise is relevant for evaluating the provision of aggregate insurance by international organizations. In the resulting enforceable equilibrium, there is substantially less risk sharing than in the baseline case. Private transfers as a ratio of first best transfers decline from 0.91 to 0.64 while the ratio of the variance of consumption to the variance of endowments increases from 0.27 to 0.36. Notice that this is a case in which the persistence of consumption in the enforceable equilibrium is larger than the persistence in autarky.

In columns (6) and (7), we increase the persistence of aggregate shocks, leaving their mean and variance unaffected. We do so in column (6) by increasing solely $\Gamma_{b,b}$, the probability of the bad shock repeating, while leaving $\Gamma_{g,g}$, the probability of the good shock repeating, unaltered. Note that for the mean and standard deviation of output to be the same as in the baseline economy, the values of the shocks in both states have to be higher which implies that the bad state is less painful even if more frequent. It turns out that the increase in $\Gamma_{b,b}$ causes a decrease in risk sharing as measured by both the fraction that average enforceable transfers represent of first best transfers (goes down to .771 form .905) as well as by the ratio of the variances of consumption and endowments (goes up to .310 from .271). The reason for this is likely to be related to the issue that aggregate bad times are better and more likely to last than in the baseline, making autarky less painful, which reduces the gain from cooperation.

In column (7) it is $\Gamma_{g,g}$ what we increase leaving $\Gamma_{b,b}$ unchanged to increase the autocorrelation of the aggregate shock. We again adjust the values of the shock to leave unchanged the mean and the standard deviation. This adjustment requires that the values of both states of the aggregate shock are lower, even if the bad state is less frequent. In this case the enforceable allocation gets closer to the first best relative to the baseline. The reason like in the previous economy has to with the value of autarky. In this economy, autarky is more painful because the bad states are worse than in the baseline. As a result agents are more willing to cooperate.

In column (8), we increase the mean of the aggregate process by 0.2, leaving its variance unaffected. One can think of this as a subsidy that gets distributed to everybody in the village. The effect of such a scheme, which obviously increases welfare, is to reduce the amount of risk sharing that can be sustained in equilibrium. By moving away the system from zero, the schemes moves individuals away from states with really high marginal utility of consumption. This means that the punishment implicit in autarky is not as harsh as in the baseline. Therefore there will be less risk sharing and private transfers. Notice that an increase in the mean of aggregate endowment that would also increase the variance but leave the coefficient of variation of the endowment process unchanged (such as a multiplicative shift) would leave the amount of risk sharing unaffected. This is, however, a consequence of the assumption of homotetic preferences. With a Stone-Geary Utility function an increase in the mean induced by a multiplicative shift would also reduce risk-sharing.

5 The provision of aggregate insurance under imperfect enforceability

In this section we consider the possibility that an outside agent with taxing powers, such as the government or an international organization (the World Bank), offers insurance against the aggregate shocks, an opportunity that the households within the village cannot afford, but that can be provided by an external entity. There are two important points we want to make in this section. First, we want to stress that the provision of aggregate insurance, like most government interventions does not happen in a vacuum. In all likelihood, the provision of aggregate insurance interacts with the functioning of private markets. In the first subsection, we describe what happens to the amount of risk sharing that occurs in equilibrium when, in the presence of enforceability problems, the government introduces an insurance scheme that smooths out part of the aggregate fluctuations. We call a reduction in the amount of risk sharing following the introduction of such a scheme 'crowding out'. We also show, within the framework of the model proposed above that it is possible that the provision of aggregate insurance may make individual agents worse off. Such a situation ocurrs when the crowding out induced by the policy more than offsets the benefits of the insurance that the public policy provides.

In the second subsection, we make the point that, given the effect that the provision of aggregate insurance has on the functioning of private markets and incentives, it is worth thinking about the design of such schemes carefully. In particular, we ask whether it is possible to introduce aggregate insurance schemes that avoid the crowding out of idiosyncratic insurance. We show that, in general, the answer to such a question is yes.

5.1 Crowding out results

In the model above, we can introduce aggregate insurance, provided by an external agent, in a very simple fashion. We consider transfers that are contingent on the aggregate shock only. Suppose, for simplicity, that the aggregate state can only take two values, low and high. We assume that the central government collects a premium in good aggregate states and pays out the actuarially fair amount corresponding to such a premium in aggregate bad states.[17]

The effects of such a scheme are immedetiately apparent in the model we considered above, in that they will enter both the value of autarky and the continuation value of insurable contracts. As the effect of the government scheme is equivalent to a reduction in the variance of the aggregate shock, we know already, from Table 1 that the effect of such a scheme will be a reduction in the amount of risk sharing that occurrs in equilibrium. In particular, we would have a reduction in the average size of private transfers and an increase in the ratio of the variance of consumption (net of aggregate consumption) over the variance of endowments.

Moreover, it is possible to construct examples in which the introduction of a mandatory aggregate insurance scheme makes agents worse off. Such an example is provided in Attanasio and Ríos-Rull (2000a). It may be expected that a welfare decrease would occur if we start from a situation where there is a substantial amount of risk sharing that goes on and that can be 'crowded out'. This is not the case in the example in Attanasio and Ríos-Rull (2000a), in which, shocks are very extreme and idiosyncratic shocks very persistent. In such a situation, high variance induces high risk sharing, while high persistence induces low risk sharing. It turns out that for the values used by Attanasio and Ríos-Rull (2000a) there is very little risk sharing: the ratio of variances is 0.85. However, the little risk sharing that goes on happens at crucial moments, when things are bad both at the aggregate and at the idiosyncratic level. In such a situation, the crowding out of a little

[17]One way to think about such a scheme is that the government is smoothing shocks across villages maintaining a balanced budget at each point in time. Alternatively, we could think of the possibility that the government has access to a storage technology that is not available to the individual agents.

insurance does make people worse off.

The result that the introduction of aggregate insurance can lead to a decrease in welfare is reminiscent of a similar result derived by Ligon, Thomas, and Worrall (1997) who show that the introduction of a storage technology in an economy with imperfect enforceability and no storage can lead, under certain circumstances, to a welfare decrease. The reason why this can happen is the same as the reason why the introduction of aggregate insurance might decrease welfare, that is the increase in the value of autarky and the subsequent decline in idiosyncratic risk sharing. Another relevant result, is that recently derived by Krueger and Perri (1999), who, in a model with partly insurable idiosyncratic shocks but no aggregate shocks, show that progressive taxes can reduce the amount of risk sharing by increasing the value of autarky.[18]

5.2 On the optimal design of aggregate insurance

Given the results discussed in the previous sub-section, it makes sense to ask whether it is possible to design the aggregate insurance scheme so to prevent or minimize the problems we discussed. In this subsection, we explore this possibility using material from Attanasio and Ríos-Rull (2000b).

In the model we have used above, the crowding out of idiosyncratic insurance originated from the fact that the aggregate insurance scheme increases the value of autarky and therefore decreases the individual incentives agents have to insure each other. In the absence of enforcement mechanisms, the equilibrium is sustained by the threat of depriving individual agents of future smoothing mechanisms. However, in the model we described, individual agents can deny their partners only the insurance of idiosyncratic shocks.

A possibility worth exploring, therefore, is to create a scheme that gives individuals the possibility of punishing their partners not only by denying them of the idiosyncratic insurance, but also of the aggregate one. In this subsection we consider two alternative schemes that aim at achieving this result. The main idea is to make individual play games that, in equilibrium will yield an allocation of resources which is sustained by off-equilibrium payoffs that imply the disappearence of the aggregate insurance. For this reason, such schemes avoid the crowding out of private insurance.

Some readers will have noticed the similarity of the previous paragraph to the language of implementation theory.[19] Indeed, our scheme uses some implementation theory ideas.

[18]Di Tella and MacCulloch (1999) stress similar points when considering a welfare system.

[19]Moore (1992) provides a very entartaining and useful survey of the literature. Jackson (2000) provides a more recent and excellent survey.

However, there are also important differences. Much (but not all) of this literature is quite abstract, in the sense that, while proving implementability of a given outcome in a certain situation, it does not necessarily specify the mechanism through which a given desired outcome is implemented. And sometimes these mechanisms can be quite complex and esoteric.[20] We are not particularly interested in showing the possibility of implementing first best allocations by some abstract and possibly very complicated mechanisms. Instead, in designing our games, we are guided by the principle that we want the schemes to be carried out in practice, possibly by a relatively unsophisiticated bureaucracy. This means that we weigh simplicity over arbitrary closeness to the first best. Even though we do not model explicitly the workings of the bureaucracies of developing countries, we have their limitations very much in mind.

In our discussion, we focus on purposedly simple and specific mechanisms and explore their ability to avoid some of the problems discussed in the previous section. These are not necessarily the optimal mechanisms and do not necessarily avoid the problem completely, as we will see below.[21] Moreover, in our mechanism, we do not use the type of mechanisms suggested in the implementation literature for the case in which there are at least three individuals. It should be stressed, however, that our 'implementation' problem is simplified by the fact that the games will be constructing are not zero-sum: we can use the utility provided by the smoothing of aggregate shocks (that is not available in the absence of the aggregate scheme we construct) as a possible carrot and stick to implement the desired outcomes.

As we have said we explore two different schemes. Each of these schemes involves making the agents play a simple game in each period when the aggregate state is bad. The payouts the World Bank gives depend on how the agents play this game. The first scheme that we explore is very simple but the equilibrium that we call for and that leaves the value of autarky unaffected does not dominate other equilibria in which the value of autarky changes with the introduction of the scheme in the same way as describe above. Indeed, treated as a one-shot game, such an equilibrium (which, as we discuss below, involves both agents playing 'no') doesn't look very convincing, as it is dominated by another Nash equilibrium (yes, yes); neither equilibrium is strict (i.e., such that your payoff strictly falls should you unilaterally deviate from it) and indeed (yes, no) and (no, yes) are also equilbria.

The second scheme, instead, while being slightly more complex, avoids some, but not all, of these problems by providing stronger incentives to implement punishment off the

[20] An important set of results state that when there are more than three agents, many outcomes are easily implementable (see Moore and Repullo (1988).

[21] And certainly they do not necessarily achieve the first best allocation.

equilibrium and, at the same time, changes the value of autarky very little, making it more robust to the problem of the agents coordinating on an unattractive equilibrium. It consists in adding a small reward for saying no. This breaks the tie, and makes the one shot game a coordination game.

5.2.1 A simple scheme

The first scheme we propose is very simple. We require, on the part of the institution providing the aggregate insurance, knowledge of the typical size of the extended families.[22] Therefore, in the model we presented above, we assume that such an institution knows the fact that extended families are formed of two individuals. When introducing the scheme, individuals are requested to register as pairs. In good times they will pay, as before, a premium and in bad times they might be entitled to a payment which is the actuarually fair value of the premium paid. However, such payment is not automatic, but it is conditional on the outcome of a game. Such a game consists in asking simultaneously and separately the two agents in a pair whether the payment to the other individual should be executed. That is, whether an individual receives her payment or not depends on what the other individual says.

In the following matrix we describe the payoff structure of the game that is playes every time a bad aggregate shock strikes the village. Note that it is the type of game that Moulin (1986) calls *give your friend a favor*, since your actions do not affect your own payoff only the other players. In our case we use it as a gate to do the opposite and give your relative a punishment.

First Scheme: The simple scheme payoff structure

[22] It is likely, though that the institution may offer a menu of deals depending on the size of families that show up at registration time. We leave for future research the issue of coexistence of family sizes.

	2 says yes	2 says no
1 says yes	$\{P, P\}$	$\{0, P\}$
1 says no	$\{P, 0\}$	$\{0, 0\}$

As is evident, such a mechanism gives each agent the possibility of punishing her partner, when and if the relationship breaks down, by depriving him not only of the idiosyncratic transfer but also of the aggregate payment. It is easy to construct equilibria for the repeated game between the two players of the following type. Say yes if the other agent has colaborated (given the transfer required by the contract) and play no otherwise. This is of course not the unique equilibria. In fact, if ever a player deviates, playing no is not even a strictly dominant strategy given that the other player says no.

Notice that the equilibrium that we describe has the feature that the stick the agents face when they deviate is unaffected by the government's policy, except, possibly, for the premium they will be paying in aggregate good times. This scheme, therefore, not only will avoid the crowding out, but will induce some crowding in. The reason for this is that by providing aggregate insurance conditional on the relationship lasting, we increase the value of being in the contract while at the same time lowering the value of autarky (because of the presence of the premium in good times which, in autarky, will not be compensated by a payment in bad times if agents play {no,no}). This causes the amount of individual risk sharing to increase. For instance, if the World Bank introduces an aggregate insurance scheme that reduces the variance of aggregate shocks by an amount equivalent to the reduction in aggregate variance discussed in column 5 of Table 1, the ratio of the variance of consumption to endowments (which is inversely related to the amount of risk sharing that is sustainable in equilibrium) which increased from 0.27 in column 1 to 0.38 in column 5, is actually reduced to almost zero when the scheme is supplemented by the simple game we propose here. And it should be stressed that not all the job is done by the reduction in the value of autarky induced by the tax in aggregate good times. Even if we assume that the government disappears once the first no,no is played (so that the value of autarky is effectively not affected by the scheme), the ratio of variances goes down to 0.026, indicating that allocations very similar to first best can be achieved in the new equilibrium.

This result is important because it shows that the government or the relevant international institution can kill two birds with one stone. On the one hand, it can smooth shocks across villages. At the same time, by carefully constructing the aggregate insurance scheme, it can use the extra utility it provides as a discipline device that improves the functioning of the private insurance market.

Notice that the scheme we propose does not require that the managing institution has knowledge of who the members of the extended family are. In our framework, the members of the family will have an incentive to register as a pair, so to pre-commit to an ex-ante better equilibrium.

Given the 'crowding in' result, it is legitimate to ask whether such a scheme can achieve first best. The answer is, in general, no. Obviously, if the variance of the aggregate shock is sufficiently high, the amount at stake becomes large enough to make the first best allocation self-enforcing. This is, however, a limit case. Obviously, as it is the case in most repeated interactions a folk-theorem can be proved. Such a theorem states that for sufficiently high discount rates, the first best can be achieved. When we state that the first best cannot be achieved in general we take the standard position in economics that discount rates are part of the environment and that cannot be manipulated by the researcher.

The main conceptual problem with this scheme is that, off the equilibrium, each agent will not have a strong incentive to punish her partner by denying him the aggregate payment. In particular, as such an action does not strictly dominate the alternative of allowing the partner to collect the payment, there are other equilibria in addition to the desirable one, where the two partners never deny each other the aggregate payment in bad aggregate states. This implies that the value of autarky will change with the introduction of the scheme in the same way as it would change if the scheme was introduced without the game. To avoid these unicity problems we turn now to a more complex scheme.

5.2.2 A scheme that rewards the nay-sayers

Our second scheme works as follows. As in the simpler case described earlier, to participate into the scheme, individuals are asked to register as a pair. However, in bad aggregate states the game the two agents, labeled 1 and 2, are asked to play is described by the matrix below.

Second Scheme: The payoff structure that rewards naysayers

	2 says yes	2 says no
1 says yes	$\{P, P\}$	$\{0, P+e\}$
1 says no	$\{P+e, 0\}$	$\{e, e\}$

The entries in the four cells describe the monetary payoffs the two agents receive (depending on which both of them play) in the period they play the game. P, as before, is the actuarually fair payment of the aggregate insurance scheme. e, instead, is a small additional transfer to those that say no; e is considerably smaller than P. In this scheme each agent has the possibility of getting, in addition to the basic payment P a transfer e. In getting the transfer e, however, the agent will deny her partner the aggregate payment P . This game is played everytime the aggregate state is bad.

Notice that, for each agent it is necessarily true that, in autarky, $P+e$ is preferred to P. Seen as a static one shot game, this is a standard prisoner dilemma and {no,no} is its only Nash equilibrium.

We assume that the sequence of events is as follows. First the state of the world gets revealed. Second, agents make their private transfers. Then, in bad aggregate states they play the game above. Finally, they consume their disposable income (made of their endowment plus net private transfers, plus what they get from the government in case they play the game above.

To analyse the welfare consequences of this game we, once again, run some simulations. The first issue we have to solve is how to compute the equilibrium in a situation where the game played is not static but is played everytime the bad aggregate state occurs. Under first best allocation, it is trivial to show that, as long as e is small, playing {yes,yes} is the only equilibrium. We then compute the value of autarky by assuming that when the relationship breaks down, the two players play the game taking into account what the other is likely to do in the future. It turns out that in most situation, playing {no,no} is an equilibrium.[23] Under this assumption, the value of autarky is left, for small values of e, almost unaffected (and indeed slightly decreased because of the premium payed in good states). Therefore we will have the same level of risk sharing achieved by our first scheme under the assumption that in autarky both agents would choose the 'right' equilibrium ({no,no}.

Such a scheme could be generalized to include a further punishment for the agent to whom the aggregate payment is denied, say k.

In this case the scheme would look like:

	2 says yes	2 says no
1 says yes	$\{P, P\}$	$\{-k, P+e\}$
1 says no	$\{P+e, -k\}$	$\{e-k, e-k\}$

By making k large enough, one can decrease the value of autarky substantially. Therefore the system goes closer and closed to the first best allocation. However, [[even though even though we have not model it explicitly,]] it is not extremely realistic to assume that the World Bank or another centralized organization goes to a village affected by a bad aggregate shock and credibly threaten to remove resources from the agents in that village. This is why we prefer to stick to the simpler, if slightly less efficient, scheme we discuss above.

[23] Such an equilibrium is not likely to b unique. However, unicity problems are standard in repeated games frameworks. The game we are considering now, however, is much better than the previous one in which we had multiple equilibria even when the game was considered as a static one.

6 Conclusions

In this paper we have discussed models of imperfect risk sharing. We have mainly focussed on models where first best allocation of resources might not be achieved because of the presence of enforceability problems. We have shown that these models provide a useful tool that allow us to characterize deviations from first best. Moreover, we have stressed that self-enforceable contracts are hybrids of insurance and debt contracts and that the pattern of transfers they give rise to might differ substantially from those one would observe under first best.

We believe that this class of models is extremely useful and relevant to characterize poor developing economies where information problems within the economy might be relatively few and yet few institutions that enforce contracts might exist. If, at the same time it might be difficult to convey the information within the economy to agents to the outside (such as courts), it might be difficult to enter contracts that are not self-enforcing.

Given these considerations, any government intervention aimed at providing insurance within these village economies, it is bound to interfere with the working of private contracts and transfers. Indeed we showed that there might be situations in which a well meaning government might, by supplying insurance against aggregate shocks, crowd out so much the private transfers as to make individuals worse off. And even when this does not happen, it is worth to think about the implications that a government scheme has on private markets and design it in a way to minimize their disruption.

In the final section of the paper we tackle the issue of the optimal provision of aggregate insurance directly and show that there might be large payoffs to the careful design of such a scheme. Not only one can design it in a way to avoid the crowding out but, in doing so, one would actually improve the functioning of private markets. We constructed simple schemes, which could realistically be implemented by a fairly unsophisticated bureaucracy, that have this property.

Much work still needs to be done, especially in testing empirically the implications of the models we have discussed.

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