RURAL POVERTY, RISK, AND DEVELOPMENT

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TABLE OF CONTENT **page**

EXECUTIVE SUMMARY

This report investigates the relationships between rural poverty, risk, and development. Over their lifetime, all men and women are subject to risk. Some external shocks affect their well being in the most direct manner: illness, accident, death. Other shocks affect their ability to support and feed themselves, either temporarily -- unemployment, crop failure, loss of property -- or permanently -- disability, skill obsolescence. The purpose of this report is to summarize what we know and do not know about the sources of risk faced by the rural poor and the coping strategies they have developed to deal with shocks. We also examine how risk and risk coping strategies impact the rural poor's capacity to develop. So doing, a better handle can be gained on how governments and international organizations can assist the rural poor to better deal with risk and overcome their poverty.

The paper starts with a brief overview of the issues surrounding poverty and risk in underveloped rural areas. Not only is risk higher in poor rural economies, but poor people are also less able to deal with risk. Apart from localized efforts, they are largely left to their own devices as far as socialized care is concerned. Low assets also make it difficult to absorb shocks. Poverty is thus not only associated with higher ambiant risk; it also reduces people's capacity to absorb shocks.

In response, the rural poor have developed a variety of strategies for coping with risk. These multi-faceted strategies include: settling relatively safe areas; breeding plants and species that survive in difficult environments; diversifying sources of income; preserving flexibility and keeping options open; accumulating precautionary saving; forming strong and large households; seeking the protection of the rich and powerful; and sharing risk with a large network of friends and relatives.

These strategies are subject to serious technological, environmental, and economic constraints that limit their effectiveness. Commitment failure, in particular, seriously limits society's capacity to share risk. This may explain the formation of long-term solidarity relationships with networks of friends and relatives. Moral norms and village ideologies can similarly be seen as attempts to mitigate the perverse effects that self-interest and information asymmetries have on mutual insurance.

The relationship between risk, poverty, and economic development is complex but our understanding has progressed dramatically with recent theoretical and empirical advances. Chronic rural poverty, by itself, is unlikely to raise net fertility. It also seldom leads to starvation -- except in cases of extreme destitution. Rather, it negatively impact welfare by raising vulnerability to adverse shocks. The effects of these shocks manifest themselves not only in terms of short-term reduction in consumption but also in terms of reduced ability to deal with subsequent shocks. In this sense, risk is fundamental to the reproduction of poverty over time.

Next, we examine discussed the relationship between rural poverty, risk, and technological innovation. We revisit the traditional risk aversion explanation and discuss many of its shortcomings. We also discuss the relationship between poverty, risk, and experimentation with new technologies and we identify the non-divisibility of technology and its learning process as a major stumbling block on the road to adoption by poor farmers. We argue that the variance of output is, by itself, unimportant, except inasmuch as it raises fears of bankruptcy. The main factors that hinders technology adoption by poor risk averse farmers are likely to be: large cash outlays, loss of diversification after adoption, and large risk during experimentation and learning.

We then turn toward credit constraints and saving and show that poor individuals with a precautionary motive for saving find it very hard to save enough to finance a large lumpy investment. The link between poverty and low investment apparent in these results is reminiscent of ’vicious circle’ and ’big push’ theories of development propounded decades ago.

In the final part of this report, we discuss the relationship between risk sharing and risk taking. Communities subject to lots of external shocks might fear the concentration of wealth that would naturally arise, were asset and credit markets allowed to freely develop. In order to ensure long-term social cohesion, these communities might institute egalitarian norms that prohibit certain transactions and require the redistribution of material wealth. We then investigate whether egalitarian norms of redistribution dilute incentives to invest. Social stratification based on patronage is likely to be inimical to large scale industrialization but to favor the accumulation of social capital, an essential ingredient in trade.

Although we have learned a lot about risk and rural poverty, there remains a lot to be learned. Little is known, for instance, about geographical patterns of rural settlement and resettlement. Yet many areas where the rural poor currently live are unsustainable. In the long run and we need to know what will motivate them to move out of these areas. More research needs to be done on financial saving by the poor and the retailing of safe savings instruments to rural areas. The household formation process plays a key role in how individuals cope with risk; unfortunately, we know precious little about what brings individuals together to form household units and how resources are allocated within these units. The formation and maintainance of social networks alse deserves further study, as well as the relationship between risk and power. The effect of poverty on development is also not fully understood, with many ideas being proposed but few scrutinized rigorously.

In conclusion, we make a series of specific suggestions regarding policy action by governments and international organizations. These recommentations focus on settlement patterns, disease prevention, savings instruments, divisible technology, and support to existing informal institutions. International organizations must continue to serve its role of insurer of last resort in times of crisis, with as little of a political agenda as possible. They should also support efforts where cross-country externalities are large and returns to scale important, such as in the eradication of diseases and pests, the development of vaccines, and agricultural research. They can also assist poor countries gain access to European and US markets for the agricultural products and crafts that the rural poor can produce, such as sugar, vegetable oils, livestock, and feed crops.

INTRODUCTION

This report investigates the relationships between rural poverty, risk, and development. Building upon the author’s work in the area, it summarizes the contributions of recent theoretical and empirical work to our understanding of rural poverty and risk in developing countries.

Over their lifetime, all men and women are subject to a wide variety of risks. Some of these risks affect their well being in the most direct manner: illness, accident, death. Others affect their ability to support and feed themselves, either temporarily -- unemployment, crop failure, loss of property -- or permanently -- disability, business failure, skill obsolescence. In addition to risk, the human life-cycle is such that all men and women, at some time in their life, are incapable of taking care of themselves even in the best of times. This is certainly true of infants and small children; it is also true of many of the elderly.

All human societies have developed ways of mitigating the effects of risk on the welfare of their members. Certain societies are better at it than others, however. Moreover, the extent, frequency, and severity of risk varies with environmental and economic circumstances. The purpose of this report is to summarize what we know and do not know about risk and risk coping strategies among poor rural societies of the world today. So doing, it is hoped that a better handle can be gained on what governments and international organizations can do to assist the rural poor to better deal with risk. The paper starts with a brief overview of the issues surrounding poverty and risk in underveloped rural areas. It continues with a review of the strategies the poor have developed to deal with risk. Next the limits to these strategies are examined. It then focuses on the relationship between rural poverty, risk, and economic development and examine how risk reduces the poor’s capacity to accumulate, innovate, and develop. Finally of the lessons learned and their policy implications are discussed.

CHAPTER 1. RISK AND POVERTY

Section 1. Life and Risk

Life is subject to all kinds of fluctuations. Some of these fluctuations are predictable: the absence of rain in the dry season, the utter helplessness of the newborn, the declining strength of the old. Others occur in a haphazard fashion that cannot be predicted, at least not precisely. These fluctuations constitute the rythm of life. They must be dealt with, in one way or another, otherwise life can become highly unpleasant. Taking care of these fluctuations constitutes risk coping strategies. The main concern is with the strategies people use to minimize the impact of these fluctuations on their welfare. Thus, the definition of risk factors encompasses both predictable and unpredictable variations in income and health.

In a recent review of informal insurance mechanisms, Morduch (1997) proposes three conceptual distinctions that are useful to characterize risk factors in general: high and low frequency risks; autocorrelated and non-autocorrelated risks; and collective and idiosyncratic risks. These distinctions are followed here and a fourth one is added: between utility and income risks.

High and low frequency risk: Risk is, by definition, a process that unfolds over time. Certain risk factors such as minor illnesses occur very frequently; others such as locust attacks are fortunately quite rare. As a first approximation, of individual risk factors can be thought of as being realizations of a Poisson process in which the number of occurrences $Z_j(t)$ of a particular shock j over a time interval t follow:

$$Prob\ [Z_j(t) = z] = \frac{e^{-\nu_j\, t}\ \nu_j^{\,z}\ t^z}{z\,!} \tag{1}$$

where parameter ν_j denotes the mean rate of occurence of shock j (e.g., Mood, Graybill and Boes (1974), p.95). High frequency risk factors are those with high ν_j, low frequency risk factors with a low ν_j. Other things being equal, high frequency risks are more dangerous than low frequency risks.

Low intensity and high intensity risks: To judge how serious a risk factor j is, however, one must also know its intensity s_j: obviously, high frequency risk factors that only have a minor incidence on someone's welfare -- e.g., an insect bite -- are less serious than low frequency risk that have dramatic consequences -- e.g., cancer. If we aggregate risk factors of different frequencies and intensities together, we can represent the risk faced by individual i at time t by a single risk vector $\pi_{it} = -\sum_j z_{jit}\ s_{jit}$, with an associated probability distribution derived from those of the z_j's and s_j's. By convention, we shall think of low values of π_{it} as representing unfavorable events -- bad health, low income -- and high values as representing good events.

Autocorrelated and non-stationary risk: The Poisson process discussed above assumes that shock realizations are independently distributed over time. This need not be the case. Malnutrition, for instance, reduces the resistance of the organism to common diseases. Exposure to one type of risk -- e.g., crop failure -- may lead to malnutrition which, in turn, raises vulnerability to other risk factors. In this case, the distribution of π_{it} is autocorrelated over time. Risk may also be non-stationary. Certain shocks indeed have a permanent effect on people's health or capacity to generate income. Perhaps the most dramatic example of non-stationarity is simply death: this shock is quite permanent. Catching an incurable disease, becoming permanently disabled, or losing productive assets are other examples of sources of non-stationarity.

Collective and idiosyncratic risk: Shocks not only vary over time; they also vary across individuals. The literature on risk customarily distinguishes between collective risk factors that affect a group, such as droughts, epidemics, and warfare, and idiosyncratic risk factors that affect isolated individuals, such as illness, unemployment, or accident. This definition, however, is not sufficiently precise to be workable. For instance, what percentage of farmers must be affected by crop failure or disease before one calls it a drought or an epidemic? To obtain a more precise definition, let the risk faced by the collection of individuals $i \in N$ be defined as:

$$\Pi_t \equiv \frac{1}{N} \sum_{i \in N} \pi_{it} \tag{2}$$

Idiosyncratic risk θ_{it} then is:

$$\theta_{it} \equiv \pi_{it} - \Pi_t \tag{3}$$

The central limit theorem implies that, if individual risks π_{it} are independent among individuals and if the group is large, then collective risk Π_t is approximatively 0 for all t. The extent of collective risk therefore depends on the size of the group and the extent to which risks π_{it} are correlated across individuals: the smaller the group and the higher the correlation between the π_{it}'s, the higher collective risk is.

Utility and income risk: So far, we have treated risk as if it were an undifferenciated quantity. There is, however, a drastic difference between those risk factors that affect individual welfare or utility directly, and those that affect income and wealth only. We shall call the former utility risk and the latter income risk. In practice, however, the boundary between the two might be blurred. Disease and disability, for instance, affect welfare directly and in this sense are a form of utility risk. But they may also have an effect on income if they strike workers. In contrast, unemployment and crop failure affect income directly and in this sense are a form of income risk. But they may also have an indirect effect on self-esteem and quality of life, which would be a form of utility risk. The classification of particular sources of risk as utility or income risk is thus a matter of degree. The distinction is nevertheless useful because analyses of risk coping strategies often ignore utility risk and focus exclusively on income risk, e.g., as when they evaluate the economic impact of diseases in terms of income loss, not in terms of pain and suffering.

If not adequately dealt with, income risk creates unwanted fluctuations in consumption. In this context, agents' ability to deal with risk can be measured by their capacity to smooth consumption expenditures over time and across states of nature. In contrast, utility risk induces voluntary fluctuations in consumption because, in their effort to mitigate the effect of utility risk on their welfare, individuals typically incur additional consumption expenditures, such as purchasing drugs and medical services. This distinction is important and has not received enough attention in the literature.[1] We shall get back to it later in this report.

Ritual risk: There is yet another type of risk that does not fit easily in either the utility or the income risk category. In many societies, social customs dictate that customary expenditures be incurred to mark particular events. Some of these events are fairly predictable; others are not. These customary expenditures serve many purposes, one of which is to rythm the life

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[1] Many authors, for instance, implicitly assimilate risk coping to consumption smoothing (e.g., Mace (1991), Cochrane (1991), Townsend (1994), Morduch (1991)).

of a group and demonstrate its cohesiveness. For instance, the party that parents feel obliged to organize to celebrate the birth of a new son or the death of a close parent fall into this category. Other ritual expenditures include the consumption of sheep at Tabaski,[2] ritual payments to the paramount chief, family reunions at seasonal holidays, and the like. The risk that is induced by ritual obligations is different from other sources of risk in that it results from social pressure more than physical need. It is people's desire to live up to social expectations and to ascertain their continued membership to a group that induces them to abide by its social norms. To capture these differences, this category is called ritual risk.[3] Given the lack of economic work in this area (see, however, Fafchamps and Lund (1999)), ritual risk will not receive further attention here. Evidence nevertheless suggests that efforts to meet excessive social obligations -- wedding ceremory, dowry payment -- are an important engine of poverty as household enter into debt to meet them. This issue deserves further inquiry.

Section 2. Risk in Poor Rural Economies

The general categories of risk discussed so far apply to all societies. The precise sources of risk to which are exposed rural inhabitants of poor countries are quite different from those observed elsewhere, however (see for instance Binswanger and Rosenzweig (1986), Binswanger and McIntire (1987), Bromley and Chavas (1989) for a discussion). Certain types of risk affect developed economies but are essentially non-existent in poor rural economies, such as trade cycle fluctuations, stock market plunges, technological obsolescence, and product cycles. But in general, risk is more prevalent in rural areas of the Third World than in developed economies.

For one thing, poor rural economies are characterized by a much higher incidence of diseases and environmental hazards. Infectious diseases such as measles, tetanus, and tuberculosis, to name but a few, are much more prevalent than in the developed world. Parasitic infections carried by water or insects are common place and they take a tremendous toll on people and animals alike. Malaria alone -- an endemic disease in many parts of the Third World -- kills millions of people every year. Pests and weeds abound that affect trees and crops. The combined dammages caused to crops in the field and in storage by insects, birds, monkeys, rats, and other wildlife are enormous. People also suffer from proximity to wild animals. It is, for instance, not uncommon for children living in the Third World today to be gobled up by crocodiles or trampled by elephants. In fact, the range of health hazards one is exposed to by living in rural poor areas is so daunting that people fortunate enough to live elsewhere often simply refuse to go there at all. It is therefore not surprising that every year millions of Third World inhabitants leave the countryside for the relative safety of the city.

Business risk is a second important risk factor. This follows from the fact that the large majority of households living in poor rural economies have at least one -- and possibly several -- businesses: a farm, an artisanal workshop, a trading activity, or a service operation. This stands in sharp contrast with the employment structure of developed economies where most people work for a wage and are thereby relatively immune to business risk, except through unemployment. The rudimentary technology of these production activities, especially

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[2] A muslim holiday.

[3] Strictly speaking, one could argue that ritual and utility risks are one and the same. One's inability to buy drugs for a sick child or to consume a sheep at Tabaski leads to a loss of welfare. Both thus induce people to incur certain expenditures to smooth their utility. Economists, however, have traditionally paid a lot of attention to utility risk, but, unlike anthropologists, they have largely ignored ritual risk. This legacy of neglect militates in favor of making the distinction.

farming, offers little protection against natural events. In addition, most of the businesses found in poor rural areas are small, undercapitalized, and underequipped, and thus very vulnerable to shocks (e.g., Daniels (1994)). Rural wage employment, when it exists, is typically casual, not permanent.[4] Unemployment risk is thus quite high as well. The frequency with which rural dwellers move in and out of a job or business is thus very high, and so is the potential for income instability.

The extent of business risk is magnified by the high dependence of poor economies on the export of a few primary products (e.g., The World Bank (1989), Deaton and Miller (1996)). Fluctuations in the price or output of these primary products represent massive macroeconomic shocks that ripple through the entire economy and affect rural dwellers in various ways, such as through the prices of agricultural outputs and inputs, the value of rural assets, access to off-farm job opportunities, and remittances from migrants (e.g., Fafchamps and Gavian (1997)). Large collective shocks such as droughts and warfare also have deleterious effects on the demand for farm and non-farm products, and thus on business and wage incomes. Sen (1981), for instance, in his account of the Ethiopian famine of 1973 points out that the categories of households worst hit by the famine were not farmers but artisans and domestic workers: the collapse in the demand for their goods and services resulted in an entitlement failure.

The vulnerability of rural businesses to idiosyncratic and sectoral technology shocks also leads to poor levels of contractual compliance. Business risk thus tends to ripple through the rural economy. Moreover, shocks are so frequent that it is easy for opportunists to falsely claim being unable to comply with their contractual obligations due to circumstances beyond their control. True business risk is thus compounded by opportunistic risk. The anthropology and rural sociology literatures abound with horror stories about unfulfilled orders, labor absenteism, broken contracts, and low quality of service (e.g., Poewe (1989)). In some instances, the fear of breach of contract is so severe that markets are totally inexistent. For example, the absence of an active rental market for bullocks and oxen in India or Ethiopia has been blamed on owners' fear that renters will mistreat the animals. The literature on sharecropping and agrarian structure in developing countries similarly emphasizes moral hazard and the high cost of supervising workers (e.g., Eswaran and Kotwal (1985), Feder (1985)). Although contractual risk has been little studied empirically,[5] there is sufficient circumstancial evidence to suspect that it constitutes a non-negligible addition to the risk faced by rural dwellers.

Risk factors inherent to the presence of environmental and health hazards, the importance of self-employment and casual labor contracts, and the fragility of the macro-economy are further compounded by the relative isolation of many poor rural communities. Imperfect spatial integration of markets for agricultural outputs, labor, assets, and the like implies that the geographical pooling of market risk is not fully achieved (e.g., Ravallion (1986), Baulch (1997), Fafchamps and Gavian (1996)). At first glance, it might seem that market integration, even if imperfect, is preferable to complete isolation (e.g., Fafchamps (1992)). This need not be the case, however, as suggested by two papers devoted to Sahelian livestock markets by Fafchamps and Gavian (1996), Fafchamps and Gavian (1997). The authors show that

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[4] E.g., Bardhan (1984), Reardon (1997), Foster and Rosenzweig ((forthcoming)), Foster and Rosenzweig (1993). There are some exceptions (e.g., Dutta, Ray and Sengupta (1989), Schaffner (1995)).

[5] See, however, Hart (1988), Fafchamps (1996), Fafchamps (1997), Fafchamps, Gunning and Oostendorp (1997) for evidence of contractual risk in urban areas.

livestock markets in Niger are sufficiently integrated to make prices respond to large aggregate shocks, but not enough to smooth out local price variations. This outcome can be understood as a consequence of transactions costs: erratic fluctuations in local livestock supply and demand do not necessarily trigger arbitrage because of transport costs; but large aggregate demand or supply shocks affect prices whenever animals are traded over space. Although limited market integration has enabled Nigerien livestock producers to partake to the fruits of commodity booms in Niger and Nigeria, in terms of risk the result appears worse than complete isolation or perfect market integration. A similar situation is likely to prevail for labor and rural commodities.

In addition to having poor transport infrastructure, poor economies also have fragile or inexistent social programs. Although governments vary in their willingness to provide a minimum level of social services to their population (e.g., The World Bank (1989)), low provision is largely a consequence of the fact that poor economies cannot afford such programs. With the exception of a handful of well documented exceptions (e.g., Kerala, Cuba until the late 1980’s), the delivery of health services, for instance, is problematic in most rural areas of the Third World. Hospitals and clinics are seldom available and, when they are, drugs and staff are often lacking (e.g., The World Bank (1989)). Insufficient health services naturally thwart efforts of individuals to mitigate the effect of utility risk on their welfare (e.g., Leonard (1996)). Socialized care for orphan children, the old, the disabled, or the mentally handicapped is similarly absent or insufficient. Whether public or private, retirement insurance is usually limited to formal employment in cities and the public sector. Finally, the funding of social programs, when they exist, are dependent on macro-economic conditions: comes a commodity price or structural adjustment crunch, funding disappears and existing programs become empty shells. Apart from localized efforts by churches, NGO’s, and occasional government programs, poor rural areas are largely left to their own devices as far as socialized care is concerned.

Not only is risk higher in poor rural economies, but poor people are also less able to deal with risk. For instance, it is highly likely that malnutrition increases the body’s susceptibility to debilitating diseases. Hence it contributes to both the incidence, the morbidity, and the mortality from common diseases such as diarrhea and bronchitis. People with low incomes and wealth find it harder to buy food and shelter or to pay for health and veterinary care, when it is available. Low financial assets also make it difficult to absorb business and employment shocks at both the individual and the collective level. Poverty thus not only raises ambiant risk; it also reduces people’s capacity to absorb shocks.

These circumstances lead us to suspect that poor rural societies have developed various ways of mitigating the effect of risk on their livelihoods. Anyone interested in assisting the poor better deal with risk must first understand what these strategies are, how they work, and when they fail. This is the purpose of the next chapter.

CHAPTER II. THE RISK COPING STRATEGIES OF THE RURAL POOR

This chapter presents a conceptual summary of risk coping strategies, together with a review of the existing evidence regarding the respective roles they play in various circumstances. We divide these strategies into three categories: those that operate *ex ante* and reduce the magnitude of the shocks themselves and hence exposure to risk; those that rely on the accumulation of assets as buffer stock; and those that explicitly share risk with others. We also examine ways in which households allocate scarce resources among their members and how this allocation affect the intra-household distribution of welfare.

Section 1. Reducing Exposure to Shocks

One way to deal with risk is simply to reduce risk itself. What Morduch (1995) calls ’income smoothing’ belongs to this category. Reducing risk can be achieved in a variety of ways, all of which imply altering production choices.

1.1 Selecting and modifying the environment

One way poor societies can reduce risk is by locating themselves in areas where parasite infestation is low. Patterns of settlement in Sub-Saharan Africa and Latin America, for instance, reflect these concerns. It is probably not an accident that the East African highlands are more densely populated than other parts of Africa: malaria risk is lower at high altitudes. This is so much true that Ethiopian populations severely affected by the 1984 famine vigorously resisted their relocation from the drought prone northern highlands to wet southern lowlands. Personal accounts from students and NGO’s who assisted the Ethiopian resettlement effort indicate that many resettled people fled -- at the risk of their life -- to escape exposure to malaria and other diseases. Morbidity and mortality among those who stayed was high.[6]

By contrast to highland areas, population density in the dense tropical forest is typically very low; they are also the areas where parasitic diseases are most prevalent. Whenever people move into a tropical forest area, it is customary for them to remove much of the forest cover, at least in the immediate surroundings of their settlement, and often in the entire settled area. One of the reasons for doing so is undoubtedly to reduce exposure to disease carrying insects and to depradations from wildlife. Concerns with disease may also help explain why irrigated schemes fail to raise much popular support in Sub-Saharan Africa.[7]

Patterns of settlement also reflect the incidence of particular human and livestock illnesses. Trypanosomiasis, a livestock disease carried by the tse-tse fly, makes it difficult if not impossible to keep domestic animals in much of the humid and semi-humid lowlands of Africa. This undoubtedly contributed to the higher concentration of African livestock in semi-arid areas where livestock could be raised -- at least until the turn of the century. Increased population density in the former forest zone of Nigeria has led to a reduction in forest cover and to a concommitant decrease of tse-tse infestation, hence shifting the livestock raising boundary hundreds of kilometers southward. Onchocercosis -- also called river blindness -- is another case in point. Repeated exposure to the disease, carried by a small fly living along river beds, leads to blindness. Eradication of the fly from most of West Africa has

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[6] This is hardly surprising given that many of the resettled people were weakened by malnutrition and that a cholera epidemic was rampant among them. It is estimated that, of the one million people forcibly relocated in the wake of the 1984 Ethiopian famine, between 50,000 and 100,000 died within a year.

[7] Irrigation dams and canals often increase the risk of malaria and other parasitic diseases.

generated dramatic movements of population to settle previously unoccupied river valleys. As a byproduct, these movements have resulted in the loss of much of the remaining wildlife habitat in West Africa.

The threat imposed by proximity to wildlife can also be tackled directly. Hunting is undertaken not only to collect bush meat but also to get rid of pests. Poaching -- and the protection granted to poachers by villagers -- can be understood in the same light. Certain traditional practices, such as burning field vegetation and pastures, can similarly be understood as ways of controlling rodents and snakes. Even when they do not actively campaign to get rid of wildlife, people protect themselves, their crops, and their animals from it. Most East African pastoralists, for instance, carry guns as protection agains lions and other predators. Farmers often keep their livestock inside the house at night for fear of hyenas, and they camp on their fields to chase away birds and monkeys.

Having illustrated various methods by which poor societies seek to select and modify their environment, it should be emphasized that the end result is still characterized by high risk. In spite of their best efforts, the rural poor face a high degree of risk from their environment, such as climatic variability, pests, and diseases. This is because the capacity of poor, non-technological societies to effectively choose and affect their enviroment is quite limited. Other risk coping strategies must therefore be found. To these we now turn.

1.2 Specialization

Another way to reduce exposure to risk is for individuals to adopt production techniques that are resistant to pests, droughts, and other environmental risk factors. Pearl millet, an extremely sturdy cereal grown in West Africa, is perhaps the best example of such a strategy. Millet is so perfectly adapted to the peculiar conditions of the Sahel -- extreme evapotranspiration, poor sandy soils, short rainy season, erratic torrential rains -- that it has enabled human settlement in areas previously reserved to livestock raising.[8] In those areas, millet is the only cultivated plant apart from small garden crops. In areas too dry to support millet, itinerant livestock herding becomes the only production activity. In these two examples, specialization in a single, robust production technique is the main income smoothing technique.

1.3 Diversification

In other situations, risk coping is achieved via portfolio diversification instead of specialization. Rural inhabitants often seek to minimize their exposure to risk by diversifying their portfolio of income generating activities. In areas with less extreme climatic conditions, for instance, farmers often plant different crops, or several varieties of the same crop to obtain a more stable output. Intercropping, that is, planting several crops in the same field is often partially justified by risk considerations as well. Similarly, livestock producers typically combine different species of animals into a single herd to take advantage of differences in their resistance to diseases and drought. Herders also split their livestock holdings into spatially distinct herds to hedge against spatial differences in rainfall. Diversification is also achieved by combining farm and non-farm activities within a single household. Reardon (1997), for instance, notes that 45% of Sub-Saharan incomes come from non-farm work. Percentages are even higher in Asia (e.g., Fafchamps and Lund (1999), Fafchamps and Quisumbing (1997)). Temporary migration to nearby cities, mines, and plantations can also be seen as part of a

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[8] See, for instance, Eddy (1979), Comité Ad Hoc Chargé de l’Elaboration d’un Code Rural (1989) for evidence of a steady northward movement of sedentary settlement in Niger since the turn of the century.

diversification strategy.

The conditions under which specialization or diversification are the appropriate response to risk can easily be illustrated using the concept of stochastic dominance. Consider a set of risky production activities j with net return q_j and risk factor π_j. Production of j is an increasing function of the total amount of inputs -- e.g, land, labor, capital, intermediate inputs -- allocated to it. Risk affects returns multiplicatively with $E[\pi_j] = 1$. Assume that inputs are chosen prior to observing π_j at prices w.[9] The cost function corresponding to a particular level of expected output can be written l_j where the dependence on w is ignored for notational simplicity. Net returns can thus be written:

$$q_j = l_j \pi_j \tag{4}$$

Let $F_j(\pi)$ denote the cumulative distribution function of activity j. Activity k is said to stochastically dominate activity j if:

$$F_k(\pi) \leq F_j(\theta) \quad \text{for } \mathit{all}\ \theta \tag{5}$$

with strict inequality for some π's. This definition means that the probability that the unit return is at least π is larger with activity k than with activity j for any π; in other words, j yields uniformly lower returns than k. If this is the case, any agent should choose k over j. This, however, ignores the fact that portfolios of activities may be found that stochastically dominate activity k undertaken in isolation.[10] The unit return to a portfolio is the weighted sum of individual unit returns, i.e.,:

$$\pi^p = \frac{\sum l_j \theta_j}{\sum l_j}$$

for some $\{l_j\}$ vector, with corresponding cumulative distribution function $F^p(\pi)$. If activity k stochastically dominate all possible portfolios, i.e., if $F^p(\pi) \geq F_k(\theta)$ for all π and all $F^p(.)$, then full specialization is optimal for all agents. If one portfolio exists that stochastically dominates k, then diversification is optimal for all agents.

The same reasoning can be extended to situations in which no activity stochastically dominate all the others provided that we assume that agents are expected utility maximizers. Let the utility that agent i derives from consuming c be denoted $U_i(c)$ and focus on the optimal allocation of a fixed total production expenditure l_i. Individual i will optimally choose activity k over activity j if:

$$EU_i(l_i \pi_k) > EU_i(l_i \theta_j) \tag{6}$$

By analogy with the previous example, if there exist a portfolio of activities such that:

$$EU_i(l_i \pi_k) < EU_i\left(\frac{\sum l_{ij} \pi_j}{l_i}\right) \tag{7}$$

with $\sum_j l_{ij} = l_i$, then diversification is preferred to complete specialization by individual i. If no such portfolio exists, then complete specialization is optimal for individual i. From the

[9] If certain inputs are chosen after observing π_j, then we redefine q_j as being the return to activity j net of optimally chosen *ex post* inputs. If production is subject to constant returns to scale, the optimal factor mix does not depend on the scale of production and the unit cost of production is constant. In this case, l_j is proportional to the amount of any of the factors used in producing good j.

[10] Assuming, for the time being, that the agent cannot issue securities, that is, buy insurance.

above we see that if no activity or portfolio stochastically dominates all the others, then specialization and diversification will vary among agents, depending on their resources l_i and on the shape of their utility function $U_i(.)$, that is, on their degree of risk aversion. The complete specialization of an entire region in the production of a single activity or portfolio -- e.g., millet -- is thus an indication that this activity or portfolio stochastically dominate all others.

One should not assume that risk averse people always act in a cautious manner. Whenever their survival is at stake, they may opt for very risky strategies as the ones that maximize their chance of survival. Perhaps the most striking example of such a strategy is that of Sahelian villagers who responded to the 1984 drought by switching to gold digging -- hardly a riskless activity, but certainly better than nothing.[11] A more commonly observed situation is the mass exodus of adult males in search of jobs and of women and children in search of food that accompanies famines and warfare (e.g., Sen (1981)): throwing oneself at the mercy of rogue soldiers, bandits, pirates, and other calamities is hardly a safe choice, but it may be the only one left.[12]

Desperate strategies can easily be integrated into the expected utility framework by assuming that utility falls to a minimum constant level $-K$ whenever consumption is below a given level $\underline{c}$:

$$U(c) = -K \quad \text{for } all\ c \leq \underline{c} \tag{8}$$

$\underline{c}$ can be interpreted as the starvation level of consumption. It is easy to see that someone offered two strategies with equal expected consumption $\hat{c} < \underline{c}$ but different variance will opt for the high variance alternative: so doing takes advantage of the longer tail of the high variance distribution and thus maximizes the probability of survival. A formally similar phenomenon affects firms on the verge of bankruptcy.[13] Whether people 'choose' desperate measures or are forced into them by circumstances is, to a large extent, a semantic issue. The important fact to recognize is that, when pushed into a corner, the rural poor will often take actions that increase their chance of surviving while on average making their situation worse. Running away from home when a famine strikes is a good, though dire, example (e.g., Sen (1981)).

1.4 Self-sufficiency

Another important dimension of risk is food security. Like anyone, rural households worry about being able to feed themselves. When markets are absent or not reliable, it becomes optimal for them to grow their own food (e.g., Singh, Squire and Strauss (1986)). Self-sufficiency then becomes the natural route toward food security. It has been shown elsewhere (i.e., Fafchamps (1992)) that even when food markets exist, imperfect market integration may nevertheless generate enough food price volatility so as to incite households to produce their own food. This can be shown with the following example. Consider an agent who can produce either food q_f or cash q_c but consumes only food. Suppose for simplicity that output is non-stochastic but the price of food p_f is. Production of food is preferable to production of cash whenever:

$$EU_i(q_f) > EU_i\left(\frac{q_c}{p_f}\right) \tag{9}$$

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[11] ICRISAT Burkina Faso data.

[12] Pirates' attacks on boat people fleeing war and persecution in South East Asia during the 1980's have been well documented in the press.

[13] Think of the U.S. Savings and Loans scandal, for instance.

Provided that q_c is not too much higher than q_f, risk averse agents will opt for food production as a mean of increasing food security. There is plenty of descriptive evidence that poor households produce much of their food but rigorous tests are rare. Fafchamps and Kurosaki (1997) estimate a structural model of joint production and consumption choices using data from five Pakistani villages. They uniformly reject the hypothesis that consumption preferences do not affect production choices, thus providing rigorous empirical support for the food security model.

The self-sufficiency motive need not be limited to food. Fafchamps and Kurosaki (1997), for instance, show that, in addition to food security considerations, concerns about fodder price volatility incited Punjabi farmers in Pakistan to grow their own fodder. In the absence of perfect labor markets, concerns for self-sufficiency in labor during peak periods of the year (e.g., Delgado (1979), Fafchamps (1993)) may similarly induce households to hoard manpower in the form of numerous children, visitors, and dependent adults.

One should not, however, regard food self-sufficiency as the unique or even most important strategy through which poor rural households ensure their food security. There are many rural households for whom food self-sufficiency is an unattainable objective, either because they live in areas that are inherently unsuitable for agriculture, or because they do not have sufficient production assets to produce food themselves. Barrett (1997), for instance, shows that most rural inhabitants of Madagascar are, in fact, deficit producers. A similar observation is made in Matlon (1977) for Northern Nigeria. For these people, food security is sought through alternative strategies, many of which are discussed here.

1.5 Flexibility

Another way of reducing exposure to risk is to remain flexible and deal with shocks as they unfold. To show this formally, let the return to activity j be a function of two successive exogenous shocks π_{1j} and π_{2j} and one action a with opportunity cost w. If action a must be decided before observing either of the shocks, the decision problem can be written:

$$\underset{a}{Max} \int_{-\infty}^{\infty} U[l_j(a)\pi_{1j}\pi_{2j}]dF(\pi_{1j}, \pi_{2j}) - a\ w \tag{10}$$

The solution to the above, denoted a^a, is not a function of π_{1j} or π_{2j}. If, in contrast, a is decided after observing π_{1j}, the decision problem is:

$$\underset{a}{Max} \int_{-\infty}^{\infty} U[l_j(a)\pi_{1j}\pi_{2j}]dF(\pi_{2j} \mid \pi_{1j}) - a\ w \tag{11}$$

and the optimal a, denoted a^p, is a function of π_{1j}. By comparing the two optimization problems, we see that, by application of the Le Chatelier principle, the expected utility of the decision maker is higher with a^p than with a^a:[14] optimization problem (10) is but a constrained version of optimization problem (11) where all values of a are required to be the same, no matter what value π_{1j} takes. Flexibility thus has an option value. An immediate corollary is that individuals are likely to resist changes that reduce their choices, and to spend resources expanding the alternatives open to them.

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[14] Formally, this is but an application of the general principle that open loop optimization is inferior to closed loop.

Replanting is a good example of the role of flexibility in coping with risk. In semi-arid tropics, rainfall at the onset of the rainy season is particularly erratic. It is not uncommon for rains to begin only to stop abruptly and restart several weeks later. In such circumstances, seeds planted after the early rains fail to grow. Farmers have to replant. To do so, they must have varieties that can be planted over an extended period of time and are not highly sensitive to the length of day.[15] Another example of how concerns for flexibility affects production choices can also be found in semi-arid areas with purely rainfed agriculture. There, weeding is the most time-consuming agricultural task and crop performance is largely a function of the care and timeliness with which weeding was conducted. Weeding, however, is performed half-way through the rainy season, after farmers have gained valuable information about annual rainfall. Elsewhere (i.e., Fafchamps (1993)) a model has been constructed of the weeding decision of Burkinabe farmers and the model parameters were estimated using structural estimation. It is shown that it is optimal for farmers to plant more than they can perfectly weed because, if rains are bad, they can compensate for low expected output by weeding more carefully. Since less rain also mean fewer weeds, farmers can smooth part of the fluctuation in output by adjusting their weeding effort. A consequence of this strategy is that, in a wet year, fields are not weeded properly, a feature that has long puzzled agronomists working in Africa.

Concerns for flexibility similarly explain why rural artisans are reluctant to use sophisticated equipment (it cannot be fixed easily); why many rural households keep their cash savings at home instead of in the bank (it is instantly available if needed); why they resist technological innovations that demand a strict respect of planting and harvesting dates (it reduces their capacity to adjust to external events with limited manpower); etc. The desire for flexibility also adds another motive for diversification: if one activity does not perform well, more emphasis can be put on another one. For instance, farmers who are also migrant laborers may have the necessary contacts to rapidly find a wage job and feed their family in spite of crop failure. Similarly, if a high yielding but more demanding crop fails due to lack of rain, more attention can be diverted to a drought-resistant one. Anticipating this, farmers may find it optimal to plant both.

Section 2. Saving and Liquidating Assets

So far we have discussed ways by which individuals can deal with risk by reducing risk itself. Clearly, these strategies cannot eliminate risk altogether: populations may settle in less dangerous areas, they are still subject to disease; they may diversify risk or opt for activities with a stable income stream, they cannot eliminate all risk; they may remain as flexible as possible, they cannot compensate for all the shocks -- or doing so would be prohibitively expensive. Some risk, therefore, remains that must be dealt with *ex post,* that is, after shocks have been realized.

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[15] Many plants adapt to seasons by developing what agronomists call photo-sensitivity: their maturation is sensitive to the duration of the day. Consequently, their output performance depends on the time of the year at which they are planted: if they flower too early or too late, they will not yield as much grain. As a result, photo-sensitive varieties have a narrower planting window and non photo-sensitive varieties.

[15] Matlon and Fafchamps (1989), for instance, report that 73% of non-harvest crop labor on millet goes to weeding. Similar percentage are reported for other crops. The importance of weeding is a consequence of the switch from long to short bush fallows: the disparition of forest and savannah cover favors the proliferation of parasitic weeds such as *striga,* thereby imposing an externality on farmers. See, for instance, Boserup (1965), Pingali, Bigot and Binswanger (1987) for a discussion.

2.1 Liquidating productive assets

For an individual hit by an unsurmountable shock, one obvious way to handle the situation is to liquidate productive assets in order to buy food, pay the rent, or take a child to the doctor. Asset liquidation, however, is likely to have a negative impact on future earnings. Households forced to sell their land, for instance, are likely to experience a permanent fall in income. Distress sale of productive assets are but a way to buy time in the hope that things will improve: with luck, future shocks will be better and the household will be able to purchase its assets back. This is, however, largely wishful thinking: on average, there is no reason for things to improve. Households who sell productive assets are more likely to face difficulties meeting their consumption needs in the future, and thus more likely to sell assets again.

The deleterious effects of land distress sales on long term income distribution have been studied by Zimmerman (1993). Using simulation analysis, the author shows that, independently from the initial distribution of land, the process of distress sales naturally leads to an unequal distribution of land and income. The driving force behind the conclusion is that individuals desperate enough to sell their land receive a lower price for it than what they must pay to buy it back. One common way of thinking about this problem is to assume that productive assets catch a lower price because they are less liquid. Zimmerman (1993)'s contribution is to show that, even if productive assets were perfectly liquid, general equilibrium effects induce a negative correlation between asset prices and shocks. This correlation explains why the price of distressed assets is, on average, lower than average.

Many societies recognize this problem and discourage land sales, either directly by declaring all land transactions illegal, or indirectly by defining agricultural land as publicly or communally owned (e.g., Atwood (1990), Platteau (1992)). To the extent that it is individually rational for the poor to sell land in very bad times -- and for the rich to buy it -- land sales take place anyway (e.g., Pinckney and Kimuyu (1994)). The inequalizing process of distress sales and land accumulation by a few often frustrates well-meant efforts to redistribute land more equally. It has indeed been noted that, after a land reform, land inequality often goes back to its pre-reform level within a decade or two, thus frustrating the efforts of government to permanently affect rural inequality (e.g., Bardhan (1984), Melmed-Sanjak and Carter (1991)). For this reason, many land reform programs stipulate that redistributed land is inalienable (e.g., de Janvry (1981)), a provision that, for reasons mentioned above, is hard to enforce. In practice, land redistribution is sustainable only if the income level of poor farmers can be stabilized to remain permanently above the level at which distress land sales become optimal. Ironically, this may require imposing a minimum farm size, thereby *de facto* excluding a large proportion of the population from land ownership. Stability in land distribution is then achieved by keeping part of the population landless -- an outcome that defeats the initial redistributive purpose of the reform.

Land is not the only productive asset that desperate households may wish to liquidate. Other potential candidates for liquidation include livestock, oxen, bullocks, farm tools, artisanal equipment, vehicles, and farm buildings (e.g., Rosenzweig and Wolpin (1993)). Desperate enough households may also consider liquidating their own manpower or that of their dependents. Although such practices may be relatively infrequent, they have attracted renewed attention with the public attention recently devoted to child labor. The most outrageous cases of child and immigrant labor documented in the press indeed revert around labor bonding and debt peonage. A good example is the recent case of young Chinese immigrants brought to Guam to work in sweat shops. Other forms of labor bonding and debt peonage persist the world over, even if in less obvious forms. For these reasons, and because labor bonding epitomizes the distress sale of productive assets, we devote some more discussion to it.

2.2 Labor bonding and debt peonage

Historically, voluntary enslavement or labor bonding has taken a variety of forms: indentured labor, debt peonage, serfdom, etc. Of course, to the extent that it is imposed upon dependents, e.g., children, it can hardly be called voluntary, but the process is the same. Although governments typically refuse to admit it, labor bonding remains a reality in many poor countries, despite being illegal virtually everywhere. Think of child carpet makers, prostitutes, migrant workers in sweat shops, and the like.

The logic of labor bonding is the same as that of distress land sales: faced with the choice between immediate starvation or slavery, it is rational to choose slavery (e.g., Srinivasan (1989)).[16] The puzzle is elsewhere, namely, on the demand side. Labor bonding is based on the fundamental assumption that the bonded laborer will be fed by his or her master. Short of that, there is no difference between immediate starvation and labor bonding. Thus for labor bonding to become reality, the marginal value of labor must be above the marginal cost of food. If not, bonded laborers will not find any takers. The only option left to them may be destitution.

To show this formally, let $\underline{c}$ be the survival level of food intake:[17] if workers consume less than $\underline{c}$, they cannot produce and die. Clearly, the wage rate cannot fall below the efficiency wage $\underline{c}$. Let output of individual i be a function of harvest labor l, i.e., $f(l)\,\pi_{it}$ with $f'_i(.) \geq 0$ and $f(0) = 0$. The marginal return to harvest labor on farm i is $f'_i(l)\,\pi_{it}$ where π_{it} is determined by past rainfall, etc. At the minimum possible wage $\underline{c}$, the labor demanded by household i is the level of l_i that satisfies:

$$f'_i(l_i)\,\pi_{it} = \underline{c} \qquad (12)$$

In case no such l_i can be found, set $l_i = 0$. For a low enough shock, there is nothing to harvest and $l_i = 0$: l_i is thus an increasing function of π_{it}. We can think of l_i as the number of workers whose survival can be supported by farmer i. Let the total number of workers in the community be N. Clearly, if

$$\sum_{i=1}^{N} l_i < N \qquad (13)$$

some workers will not find employment at the efficiency wage.

Now suppose that workers can credibly commit to deliver their labor power forever at wage $\underline{c}$.[18] Define i's expected discounted utility from refusing the offer as $V_i^r(F_t)$ where $V_i^r(.)$ solves the following Belman equation:

$$V_i^r(F_t, \pi_t) = \underset{l_t \geq 0,\, F_{t+1} \geq 0}{Max}\; U(\gamma F_t + f(l_t)\pi_{it} - l_t\,\underline{c} - F_{t+1}) +$$

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[16] Unvoluntary slavery -- e.g., slave raids -- is a distinct phenomenon that is ignored here. We also abstract from the fact that powerful people may use their monopoly power as food suppliers or employers of last resort to artificially rise food prices and lower wages in bad times, thereby inciting more people to voluntary propose themselves as bonded laborers.

[17] In practice, the survival level of food intake may be below that required for someone to work. This complication is ignored here.

[18] The argument can be extended to finite time bonded labor, but assuming an infinite contract simplifies the notation. Historically, indenture contracts for U.S. and Canadian immigrants were of finite duration. The discussion of whether labor bonding is credible or not, is postponed until Chapter III.

$$\beta \int_{\underline{c}}^{\infty} \int_{-\infty}^{\infty} V_i^r(F_{t+1}) d\Phi(\pi_i) dG(w) \tag{14}$$

where $\Phi(.)$ and $G(.)$ denote the cumulative distribution of shocks π_i and wages w_t, respectively.[19] Similarly, define i's expected discounted utility from accepting the offer as $V_i^a(.)$ with:

$$V_i^a(F_t, \pi_t) = \underset{l_t \geq 0,\ F_{t+1} \geq 0}{Max} U(\gamma F_t + f(\underline{s} + l_t)\pi_{it} - \underline{s}\ \underline{c} - l_t\ \underline{c} - F_{t+1}) +$$

$$\beta \int_{\underline{c}}^{\infty} \int_{-\infty}^{\infty} V_i^r(F_{t+1}) d\Phi(\pi_i) dG(w) \tag{15}$$

where $\underline{s}$ stands for bonded labor, assumed constant and inalienable.[20] An employer with food stock $\overline{F_t}$ finds a bonded labor contract appealing if:

$$V_i^a(F_t) > V_i^r(F_t) \tag{16}$$

It is easy to see that $V_i^a(F_t) - V_i^r(F_t)$ is an increasing function of F_t and π_{it}: farmers with no stock and little to harvest find it more costly to support workers today in exchange for future labor. Condition (16) will thus be satisfied if future wages and shocks are expected to be much higher than current ones and if F_t is sufficiently high so that supporting $\underline{s}$ workers today does not drastically reduce i's current consumption. Famines can be thus thought of as episodes during which the society as a whole cannot support its entire population: there is not enough food to go around so that the more fortunate do not find it profitable to support the less fortunate in exchange for their future labor.

Once this is understood, it is easy to see how bonded labor can perdure: as long as bonded laborers cannot survive on their own, it is optimal for them to remain bonded. This may explain why labor bonding perdures in certain countries in spite of being illegal.[21] The same logic applies to other forms of self-imposed long-term dependency, such as debt peonage and indentures. To the extent that these forms of dependency could easily be qualified as 'exploitative', we see that there is a close relationship between exploitative social structures, risk, and poverty. To put it differently, the fact that certain people may voluntarily put themselves entirely at the mercy of others in exchange for survival -- or, in the case of migrant workers, in exchange for the promise of a better future for themselves or their progeny -- calls for serious concern. We shall get back to these issues when we discuss patron-client relationships.

2.3 Reducing consumption to keep productive assets

As is clear from the above discussion, liquidating manpower and productive assets to deal with shocks can be extremely damaging to one's long run welfare. Consequently, it is perhaps not too surprising to find that poor rural dwellers often prefer to reduce their consumption rather than liquidating productive assets. Fafchamps, Udry and Czukas (1996), for instance, show that Burkinabe households held onto their livestock even at the height of the 1984 Sahelian drought. In contrast to Rosenzweig and Wolpin (1993) who argue that Indian

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[19] The example can easily be extended to the case where shocks and wages follow a Markov process.

[20] Setting up a market for bonded laborers -- i.e., introducing slavery -- raises the expected value from bonded labor since it introduces an additional option. This issue is ignored here.

[21] Mauritania is a case in point: it has had no less than three successive legal reforms declaring slavery illegal.

households smooth consumption through purchases and sales of bullocks, Lim and Townsend (1994) use the same Indian data to show that livestock transactions raise income volatility instead of reducing it.

Using results from livestock price analysis conducted by Fafchamps and Gavian (1996, 1997), Fafchamps, Udry and Czukas (1996) speculate that the reason why farmers are reluctant to liquidate their livestock is because livestock prices are much lower during a drought than they normally are. Similar observations can be found in the anthropological and sociological literatures on pastoralists (e.g., Sandford (1983), Monod (1975), Oba and Lusigi (1987)). The price drop during a drought implies that the returns from holding livestock are higher than normal immediately after a drought. Fafchamps (1993) shows that the variation in prices is further magnified by externalities in pasture management and by institutional failure. Another reason why results from Burkina Faso are in contrast with results from India is that in the former, land sales are not feasible while in the latter they are. This leads to a more unequal distribution of land ownership in India than in Burkina Faso and, hence, to a more egalitarian distribution of wealth in the latter. As a result, the sale of productive assets might be less of a necessity in Burkina Faso. Differences in land markets may also account for the fact that, based on casual observation and social science literature, cases of labor bonding and debt peonage are less frequent in Africa than in Asia. This issue requires additional research.

Household's desire to protect their assets is not, however, always possible if households do not have access to other ways of sharing risk. As the work of Zimmerman (1993) demonstrates, distress sales will occur even if households correctly anticipate that they will not be able to buy their assets back because of the negative correlation between shocks and asset prices. This is because survival, even at a lower level of utility, is always better than starvation.

2.4 Precautionary saving

Saving is one way by which households can protect themselves against the damaging consequences of distress sales to productive assets without having to reduce consumption: in anticipation of future shocks, households may build up liquid reserves that can be sold or consumed in times of need. In the literature this practice is commonly referred to as precautionary saving. The liquid assets that are accumulated in this manner by poor rural dwellers include food stocks, gold and jewelry, cash, and, provided a bank is closeby, deposits on savings and checking accounts (e.g., Lim and Townsend (1994), Behrman, Foster and Rosenzweig (1997)).

Hall (1978) was among the first to formalize the idea that savings can be used by households to smooth consumption. Hall considers a household with a random wage income π_t who can save in a riskless asset A_t with constant return r. The household's intertemporal optimization problem can be written:

$$\underset{\{c_t\}}{Max} E \sum_{t=1}^{T} (1+\delta)^{-t}\, U(c_t) \tag{17}$$

subject to the following budget constraint:

$$A_{t+1} = (A_t - c_t)(1+r) + \pi_t \tag{18}$$

and debt repayment constraint:

$$A_T - c_T \geq 0 \tag{19}$$

Variable A_t denotes the household's stock of liquid assets at time t, while π_t represents wage income. Parameter T is the household's horizon, possibly infinite. Constraint (19) guarantees that the household pays all its debts. If utility is quadratic and T is ∞, it can be shown (e.g., Zeldes (1989)) that:

$$c_{CEQ,t} = \frac{r}{1+r}\,(A_t + H_t) \tag{20}$$

where:

$$H_t \equiv E_t \sum_{\tau=1}^{\infty} (1+r)^{\tau}\, \pi_{t+\tau} \tag{21}$$

Variable H_t can thus be interpreted as the agent's human capital from which a wage return of $\pi_{t+\tau}$ is obtained in every period.[22] Equation (20) implies that households consume the annuity value of their combined liquid wealth and human capital. The sensitivity of consumption to current income then is:

$$\frac{d\, c_{CEQ,t}}{d\, \pi_t} = \frac{r}{1+r}\{\sum_{\tau=0}^{\infty} (1+r)^{-\tau}\, \frac{\partial\, E_t\, \pi_{t+\tau}}{\partial\, \pi_{t+\tau}}\} \tag{22}$$

If wage income π_t is uncorrelated over time, equation (22) boils down to:

$$\frac{d\, c_{CEQ,t}}{d\, \pi_t} = \frac{r}{1+r} \tag{23}$$

Equation (23) shows that, with quadratic preferences, the sensitivity of consumption to temporary variations in income is quite small -- of the order of $\frac{r}{1+r}$. The propensity to save out of temporary variations in income is predicted to be very high, i.e., of the order of $\frac{1}{1+r} \approx 1$.

Paxson (1992) tests the certainty equivalent model using savings and consumption data from Thailand. Her estimate of the propensity to save out of temporary income reverts around 0.73/0.83; she cannot reject the hypothesis that the true value is 1 (see also Paxson (1993), Chaudhuri and Paxson (1994)). She nevertheless finds that households save a portion of their permanent income as well, a finding that she interprets as circumstantial evidence in favor of credit constraints. It can also be interpreted as evidence of life cycle and bequest motives for saving (e.g., Horioka and Watanabe (1997)). Fafchamps, Udry and Czukas (1996) use a similar approach to test whether the pattern of sales and purchases of livestock by West African farmers is consistent with the use of livestock as a buffer against risk. Their results indicate that livestock is used less as a hedge against crop income risk than is commonly believed. Their finding is in line with households' willingness to incur fluctuations in consumption in order to protect productive investments (see supra). Lim and Townsend (1994) reconstruct the cash balances of poor Indian households and conclude that cash holdings play a major role in smoothing consumption. They also compute the variance of income and the variance of income plus livestock sales and purchases. If households liquidate livestock to absorb income shocks, than the second should be smaller than the former; they find the opposite, again suggesting that livestock is a productive asset that households seek to protect, not a buffer stock. Fafchamps and Lund (1999) similarly find that Filipino rural households make little use of pigs and chicken as hedges against unemployment and 'ritual' shocks (i.e., the need to finance

[22] For simplicity, human capital is here taken as given and unchanged over time. The model can be generalized to allow for human capital accumulation as well; see for instance Sawada (1997) and Jacoby and Skoufias (1995).

funerals and sickness ceremonies). All these results go against the conventional wisdom that livestock, particular small stock, play an important role in dealing with risk. More research is needed to ascertain the exact role that livestock plays in dealing with shocks.

In the certainty equivalence model, the variance of income has no influence on how much households save -- hence the 'certainty equivalence' phrase to describe the model. Intuitively, however, one would expect households facing a more risky environment to save more as a precaution against risk. Kimball (1990) provides a rigorous treatment of the precautionary motive for saving. By analogy with the Arrow-Pratt measures of risk aversion, Kimball defines a coefficient of absolute prudence η as:

$$\eta \equiv -\frac{V'''}{V''} \tag{24}$$

where $V(x)$ is the household's value function defined over cash in hand x. Absolute prudence measures the strength of the precautionary saving motive in the sense that a household faced with a mean-preserving increase in income risk increases saving proportionally to η.[23] Kimball also shows that, if absolute risk aversion is decreasing, a household who purchases full insurance at a price equal to its maximum willingness to pay increases consumption and reduces savings. An immediate corollary is that any voluntary purchase of full insurance reduces savings, another way of saying that precautionary saving is an insurance substitute.

By defining precautionary savings on the basis of the local curvature of the utility function, Kimball's approach obscures the fact that a precautionary motive for saving can arise from global properties of the utility function. To see why, let us delve for an instant into the literature on inventory stockout risk (e.g., Tsiang (1969), Krane (1994), Kahn (1987)). A simple model of stock-out risk can be found, for instance, in Fafchamps, Gunning and Oostendorp (1997). The authors construct a simple model in which firms' profits are linear in stocks, except for a sharp penalty when the firm runs out of inventories. They show that an increase in the variance of risk raises the probability that the firm runs out of stock for any given level of stock, and hence raises the inventories that the firm holds *ex ante*. The same logic can easily be applied to rural households: if running out of food stocks means starvation, agents will minimize the probability of starvation by holding stocks.[24] More risk will lead them to hold more stocks.

There is little empirical work on the relationship between the variance of income shocks and saving among the rural poor.[25] Fafchamps, Gunning and Oostendorp (1997) show that contractual risk and to a lesser extent market risk help explain the accumulation of inventories and liquidity reserves among African manufaturers.

2.5 Borrowing

We have seen that asset accumulation can serve to smooth consumption. Faced with a sufficiently long series of bad income and utility shocks, individuals will nevertheless run out of assets and will no longer be able to absorb shocks by liquidating assets. One conceivable way out of this quandary is to let households' asset position become negative, that is, to let households borrow.[26] As Carroll (1992) has shown, however, credit constraints are

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[23] Although this result does not appear as such in Kimball's analysis, it follows immediately from his work.

[24] A similar argument can be found in Roumasset (1976).

[25] See, however, Paxson (1993), Chaudhuri and Paxson (1994), Carter (1991).

[26] In fact, the ability to borrow without limit is implicit in the certainty equivalent model, e.g., Hall (1978).

unavoidable if credit contracts are strict, that is, if creditors insist on repayment under any circumstance. To see why, suppose that the lowest value taken by income π_t is π_0 and consider an individual reaching the end of his life at time T. We assume that consumption cannot be negative and that the interest rate r is constant over time. Since debt contracts must be repaid no matter what, the maximum amount the individual can borrow at time $T-1$ is π_0; any amount in excess of π_0 cannot be repaid with absolute certainty. Going back one period, by the same argument, we see that the maximum amount that can be borrowed at $T-2$ and be repaid with absolute certainty is equal to $\pi_0 + \frac{\pi_0}{1+r}$. By successive backward induction, we see that the absolute maximum that a household can borrow is $\frac{\pi_0}{r}$: strict credit contracts naturally generate credit constraints without any need for asymmetric information or enforcement problem. If $\pi_0 = 0$ -- a reasonable assumption in most cases -- individuals can never hold negative wealth.[27] For credit to exist, credit contracts must allow for conditional default, that is, must mix an element of insurance with pure credit. We shall get back to this issue later.

Zeldes (1989) examines the saving behavior of a household facing an implicit credit constraint.[28] He shows that, for sufficiently large cash in hand, the consumption behavior of the household is adequately approximated by the certainty equivalence model: the propensity to consume out of temporary income is approximately equal to the annuity value of the income shock (see supra, equation (24)). At low levels of wealth, however, consumption becomes much more sensitive to current income. At the limit, when wealth tends to zero, the propensity to consume out of current income tends to one: households who have run out of assets simply consume their current income.

Deaton (1991) extents Zeldes (1989) model to cases where $\pi_0 > 0$ but households cannot hold negative wealth. In this case, the credit constraint can be binding. Deaton shows that there exist a level of cash in hand x^* below which households consume all their current income. Only when cash in hand rises above x^* do households accumulate precautionary balances. Zeldes (1989) proposes a simple test of the credit constraint hypothesis. Following Deaton (1991), he notes that if the credit constraint is not binding, household consumption must satisfy the usual Euler condition:

$$U'_i(c_{it}) = E\left[\frac{1+r}{1+\delta}\, U'_i(c_{it+1})\right] \tag{25}$$

If, in contrast, the credit constraint is binding, then:

$$\begin{aligned} U'_i(c_{it}) &= E\left[\frac{1+r}{1+\delta}\, U'_i(c_{it+1})\right] + \lambda_t \\ &= \frac{1+r}{1+\delta}\, U'_i(c_{it+1}) + \lambda_t + \varepsilon_t \end{aligned} \tag{26}$$

where λ_t is the Lagrange multiplier associated with the credit constraint. If the constraint is

[27] They can, however, borrow against non-divisible productive assets such as land or buildings. Banks' insistence on collateral is consistent with the idea that households cannot hold negative wealth.

[28] Although a credit constraint is not explicitly imposed on the model, the requirements that consumption be non-negative and that all debt contracts be paid with certainty ensure that the agent cannot hold negative net worth.

binding, $\lambda_t > 0$; otherwise, it is 0. If utility takes the usual constant relative risk aversion form, equation (26) can be rewritten in terms of $\frac{c_{t+1}}{c_t}$ consumption and λ_t. Since λ_t is decreasing in income, the presence of credit constraint can be tested by regressing the growth rate of consumption on household characteristics and π_t. Morduch (1990) applies such a test to Indian data and concludes that the presence of a credit constraint cannot be rejected among poor and middle income farmers. Only among wealthy households can the credit constraint hypothesis be rejected -- a result entirely in line with Deaton (1991)'s analysis.

In another article, Deaton (1990) shows that, in the presence of credit constraints, the time path of consumption is characterized by infrequent but dramatic drops in consumption that he compares to famines. The rest of the time, consumption is fairly smooth in spite of large fluctuations in income. Deaton's analysis demonstrates that asset accumulation can drastically reduce fluctuations in consumption but cannot fully prevent famines. He also shows that famines only arise when households are affected by a series of successive bad shocks, a feature that has long been noted in the descriptive literature on famines (e.g., Sen (1981)).

Deaton's analysis also brings to light the fact that impatient households save even when the return on their assets is negative (e.g., Deaton (1992)). This stands in sharp contrast with a world of certainty in which households would never save when the rate of interest r is smaller than the rate of time preference δ. This theoretical prediction is consistent with the fact that poor households the world over save partly in the form of grain stocks or cash. Although grain stocks often have a positive intra-year return thanks to seasonal variations in prices, their inter-year real return is in general negative: stocks depreciate due to pests and dessica-tion. Similarly, cash and bank deposits typically have negative returns due to inflation. Yet poor people often hold much of their liquid wealth in the form of grain and cash.[29] Park (1995), for instance, shows that grain stocks in northern China are equivalent to several years of harvest. Lim and Townsend (1994) similarly argue that, among Indian households, grain and cash represent the major forms of precautionary saving.

Section 3. Risk Sharing

So far we have discussed risk coping strategies that either seek to smooth income directly or rely on the accumulation and liquidation of assets. Our entire discussion was focused on the individual. We now turn to a more aggregate approach and consider risk sharing in a general equilibrium context. Let s_t denote the state of the world at time t and be drawn from a finite set of possible events S_t with probability $Prob(s_t)$. Consider a rural community constituted of N members, each with a stream of stochastic income $\pi_{it}(s_t)$ and a utility $U_i(c_{it}(s_t))$. Pareto efficiency in the sharing of risk requires that, for any set of welfare weights ω_i, individual consumption satisfies the following social planner problem:

$$\underset{\{c_{it}\}}{Max} \sum_{i=1}^{N} \omega_i \sum_{t=1}^{\infty} (1+\delta)^{-t} \sum_{s_t \in S_t} Prob(s_t)\, U_i(c_{it}(s_t)) \tag{27}$$

subject to the feasibility constraint

$$C_t(s_t) \equiv \sum_{i=1}^{N} c_{it}(s_t) = \sum_{i=1}^{N} \pi_{it}(s_t) \equiv \Pi_t(s_t) \tag{28}$$

[29] The reader will note a close similarity between precautionary saving and Keynes' liquidity motive for holding money.

and a set of non-negativity constraints

$$c_{it}(s_t) \geq 0 \tag{29}$$

for all s_t and all t. The set of all efficient risk sharing allocations can be traced by varying the welfare weights ω_i.

This social planner model can easily be extended to allow for accumulation. Given the existence of a riskless asset A with constant return r, the feasibility constraint becomes:

$$C_t(s_t) \equiv \sum_{i=1}^{N} c_{it}(s_t) = \sum_{i=1}^{N} (\pi_{it}(s_t) + A_{it}) \equiv X_t(s_t) \tag{30}$$

where $X_t(s_t)$ denotes aggregate cash in hand.

Let $\lambda(s_t)$ be the Lagrange multiplier associated with the s_t feasibility constraint. Assuming that none of zero consumption constraints are binding, efficient risk sharing requires that:

$$\omega_i \ (1+\delta)^{-t} \ Prob(s_t) \ U'_i(c_{it}(s_t)) = \lambda(s_t) \tag{31}$$

Since $\lambda(s_t)$ depends only on aggregate income $\Pi_t(s_t)$ (with no accumulation) or aggregate cash in hand $X_t(s_t)$ (with accumulation), equation (31) implies that in a Pareto efficient allocation individual consumption can only depend on $\Pi_t(s_t)$ or $X_t(s_t)$, not on individual income.

The Pareto efficiency conditions for an interior solution can be rewritten:

$$\frac{U'_i(c_{it}(s_t))}{U'_j(c_{jt}(s_t))} = \frac{U'_i(c_{it}(s'_t))}{U'_j(c_{jt}(s'_t))} = \frac{\omega_j}{\omega_i} \tag{32}$$

From equation (32), it is easy to see that if welfare weights and utility functions are the same for two agents i and j, then:

$$c_{it}(s_t) = c_{jt}(s_t) \tag{33}$$

for all t and s_t. In this case, risk sharing is equivalent to pooling incomes and sharing them equally. If the welfare weight of individual i is higher than that of j, i's consumption is larger than j's.

The pooling of risk does not, however, require that agents mutually insure each other. To see why, suppose that one agent, say k, is risk neutral; k's marginal utility of consumption is thus constant. Equation (32) then implies an equalization of the consumption of all other agents across all states of the world, i.e.:

$$c_{it}(s_t) = c_{it}(s'_t) \tag{34}$$

for all i and all s_t, $s'_t \in S_t$. The risk neutral agent provides perfect insurance to all other agents; he or she plays the role of an insurance company. Equation (34), however, holds only along interior equilibria. For large enough shocks encountered by other agents, individual k may not have sufficient income or wealth to guarantee himself or herself a non-negative consumption. In that case, the consumption of other agents is not smoothed and the equilibrium allocation resembles one in which the 'insurance company' goes bankrupt.

Although the setup presented above has been used mainly to examine situations in which agents face both collective and idiosyncratic risk and share the latter, the presence of idiosyncratic risk is not required for insurance to take place. First, agents can find some protection from collective risk whenever attitudes toward risk differ across agents. In the presence of a risk neutral agent, for instance, agents manage to smooth their consumption perfectly provided the risk neutral agent who serves the role of insurance company has sufficiently deep pockets never to fail. Second, insurance against collective risk is even possible among agents with the same utility function and perfectly correlated incomes whenever income levels vary among agents. If agents have decreasing absolute risk aversion, for instance, it is mutually welfare increasing for agents with high average incomes to partially insure poorer agents against bad collective shocks in exchange for transfers in good states of the world. The reason is that poor agents can gain much by reducing the risk of starvation and can thus compensate rich agents for the welfare loss they incur from increased consumption volatility. Having said this, it is important to recognize that the presence of idiosyncratic risk dramatically raises the welfare gains that can be reaped through risk sharing.

The sociological and anthropological literatures abound with descriptions of insurance arrangements that ressemble the kind of protection that a risk neutral agent would provide. These arrangements are often called patron-client relationships (e.g., Scott (1976), Platteau (1995a, 1995b)) and described as implicit contracts whereby a wealthy individual provides to poorer agents protection against both idiosyncratic and collective shocks. Transfers from the poor to the rich take a variety of forms, ranging from labor services to political support. We shall discuss these arrangements more in detail below.

Equation (31) has been extensively used as a basis for testing efficient risk sharing as follows. Posit a functional form for $U_i(.)$, e.g., constant absolute risk aversion (e.g., Mace (1991), Cochrane (1991)):

$$U_i(c_{it}) = -\frac{1}{\sigma}\, e^{-\sigma(c_{it} - b_{it})} \tag{35}$$

where b_{it} is an individual-specific shifter that captures household characteristics and utility shocks such as disease or rituals. Equation (34) can be rewritten:

$$\frac{\lambda(s_t)(1+\delta)^t}{Prob(s_t)} = \omega_i\, e^{-\sigma(c_{it} - b_{it})} \tag{36}$$

Taking logs and summing over all community members, we obtain:

$$c_{it}(s_t) = \frac{1}{N}C_t(s_t) + \frac{1}{\sigma}(\log\omega_i - \log\omega_a) + b_{it} - b_{at} \tag{37}$$

where $\omega_a \equiv \frac{1}{N}\sum_{i=1}^{N}\log\omega_i$ and b_{at} is the average b_{it} in the community. Equation (37) indicates that consumption of individual i should be equal to average consumption, plus the difference between the log of i's welfare weight and the average log welfare weight, plus the difference between i's utility shifter and the average shifter. In other words, with constant absolute risk aversion individual consumption should respond to aggregate income and utility shocks and fully compensate for utility shocks b_{it}. A similar equation in logs instead of levels can be derived using constant relative risk aversion instead. First-differencing equation (37) eliminates unobservable welfare weights. If risk is shared efficiently, regressing changes in individual consumption on changes in aggregate consumption and individual income should thus yield a zero coefficient on individual income.

Following the application of this approach to U.S. data by Altonji, Hayashi and Kotlikoff (1992), Mace (1991), and Cochrane (1991),[30] equation (37) has been used by a number of authors to test whether rural communities share risk efficiently. Townsend (1994) and

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[30] Cochrane (1991) tests whether illness results in lower aggregate consumption. He concludes that short illnesses are fully insured while long illnesses are not. Stangely, however, Cochrane fails to account for the possibility that sick individuals may require *additional* consumption expenditures to deal with health care costs.

Morduch (1991) apply this approach to rural household data from India. They conclude that, although there is plenty of evidence that idiosyncratic variations in income are largely smoothed out, full Pareto efficiency is rejected in general. According to Morduch (1991), however, efficient risk sharing cannot be ruled out within sub-groups such as castes, or for food consumption alone. Using data from Pakistan, Fafchamps and Kurosaki (1997) fail to reject efficient risk sharing among villagers but find evidence that much of the variation in incomes across villages is not shared efficiently.

These tests, however, do not provide any information as to how risk is shared. Risk sharing can be explicit, as when agents trade Arrow-Debreu securities; it can be implicit, as when they trade fiat money to equalize their consumption over states of nature. Evidence of risk pooling such as that reported by Townsend (1994), Morduch (1991), Fafchamps and Kurosaki (1997), does not in any way constitute evidence that members of a community actively insure each other, a point that is not always made clear in the literature. We first consider implicit risk sharing, and then turn to explicit risk sharing mechanisms.

3.1 Implicit risk sharing

To see how implicit risk sharing is possible, consider an economy à la Akerlof (1985) in which each agent has an exclusive claim on the fruits falling from a coconut tree. Furthermore, suppose that agents can trade with each other using fiat currency, as in Sargent (1987), Chapter 3. Assume no credit market. As discussed in the previous section, agents can use their accumulated currency assets to smooth consumption: agents with few coconuts buy coconuts from luckier agents in exchange for fiat currency. Coconuts thus flow from high coconut agents to low coconut agents and risk is being shared without anyone explicitly recognizing that trade in coconut serves to share risk (e.g., Lucas (1978), Lucas (1992), Townsend (1988), Townsend (1989)).

This coconut example sounds unrealistic, but just replace ’coconut’ with ’grain’ and ’fiat currency’ with ’livestock’ and you may have a good description of an African or Indian village. The point is that, by exchanging among themselves non-consumable assets such as livestock[31] against consumable assets such as grain, villagers implicitly share risk among themselves. Similarly, by exchanging assets non-consumable for consumable assets with the rest of the world, villagers share risk with the rest of the world.

The sharing of risk via accumulation requires that markets be present for agents to trade non-consumables for consumables. Suppose, for instance, that villagers liquidate their livestock and buy grain during bad times. The extent to which this strategy enables villagers to share risk among themselves and with the rest of world depends critically on whether grain and livestock can be exchanged on the market. If they cannot, the only way villagers can protect themselves is by accumulating consumables such as grain.

In practice, market limitations are particularly serious regarding rural communities’ ability to share risk with the rest of the world and thus to smooth consumption against collective shocks. If trade in grain and livestock is possible, for instance, then livestock accumulation can serve as hedge against collective shocks. How efficiently risk is shared in this manner depends critically on the efficiency of market institutions: if the relative price of grain with

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[31] Poor rural dwellers are, in general, extremely reluctant to consume their animals in bad times; they might seek to sell them instead, as the calorie price of meat nearly always exceeds that of grain (see above). This is particularly true for large animals, perhaps less so for small stock such as goats, pigs, and chicken. See Sen (1981) and Fafchamps (1993) for a discussion.

respect to livestock is constant and the return to livestock is higher than the return to grain storage, then livestock is an effective hedge against drought risk. If, however, this relative price rises dramatically during droughts, as is often the case in Sub-Saharan Africa (e.g., Sandford (1983), Fafchamps and Gavian (1996)), then the sharing of risk across communal or regional boundaries is seriously impaired. As a result, reliance on markets may increase the degree of risk a poor household faces by exposing it to a greater likelihood of entitlement failre in case of drought or famine (Dreze and Sen, 1990). In this case, poor households may hide away from the market and seek self-sufficiency in food instead (Fafchamps, 1992).

Numerous studies have shown that grain and livestock markets in poor economies of the Third World are far from being efficient: prices in different locations often fail to co-move (e.g., Dercon (1995), Shively (1996), Fafchamps and Gavian (1996)), and price differentials often exceed measurable arbitrage costs (e.g., Baulch (1997), Arnould (1985), Fafchamps and Gavian (1996)). The reason for this state of affairs has much to do with the thinness of rural markets, which is itself related to the low productivity of agriculture (little to sell), the large number of producers (lots of transactions), and the information and enforcement problems inherent in any market. These problems are often compounded by ill-advised government interventions in rural markets. High transactions costs *de facto* isolate rural communities: they lead to insufficient arbitrage and thus to high covariance between local prices and local aggregate shocks.

3.2 Explicit risk sharing

As we have seen in our discussion of precautionary saving, individual accumulation may fail to achieve perfect consumption smoothing. First, agents may run out of assets, in which case they cannot smooth; a community's capacity to share risk among its members via individual asset accumulation thus depends on the amount and distribution of wealth among its members. The poorer the community and the more unequal the distribution of wealth, the less efficient implicit risk sharing is, and thus the higher the efficiency gain from explicit risk sharing. Second, even when agents have plenty of assets, they nevertheless consume the annuity value of the income shock (e.g., Zeldes (1989)): even in a certainty equivalent world, consumption varies with current income, and there are gains from explicit risk sharing.

There are various ways in which rural communities can organize the explicit sharing of risk. To illustrate this idea, we construct a stylized model of risk sharing inspired from models of village economies developed by Townsend (1993) and Udry (1994). Consider a group of individuals indexed by i. Let the main staple crop, e.g., rice, be the numeraire and let each individual be endowed with a production function $H^i(.)$ such that crop output q^i_{t+1} at the beginning of period $t+1$ is:

$$q^i_{t+1} = H^i(a^i_t, b^i_t, \varepsilon_{t+1}) \tag{38}$$

where a^i_t is crop labor, b^i_t stands for cash inputs, and ε_{t+1} is a vector of all the random shocks affecting the group and its members.[32] We assume that the group cannot formally share risk with the rest of the world. Individuals have three types of assets at their disposal: grain storage s^i_t, saving on a savings account L^i_t, and currency M^i_t. Through L^i_t and M^i_t and trade in grain with the rest of the world, the village as a whole can implicitly pool risk with other villages (see above). Returns on storage are assumed to take the form:

[32] Certain of these shocks such as individual sickness may not affect crop output directly but to keep notation compact we let ε_t stand for all the shocks affecting the village and its members.

$$(1-\delta)s_t^i\, g^i(\varepsilon_{t+1}) \tag{39}$$

where δ is a stock depreciation rate and $g_i(\varepsilon_{t+1})$ expresses the dependence of storage returns on exogenous shocks ε_{t+1}. The nominal rates of return on cash and savings accounts are 0 and r_l, respectively.

To the extent that members of the group trade all goods and labor efficiently among themselves, shadow prices of all commodities are determined endogenously through market equilibrium. These commodity prices are subject to aggregate shocks in supply and demand; idiosyncratic shocks, that is, shocks that cancel out in the aggregate do not affect market prices. This idea can formally be expressed by letting the prices on any traded commodity k depend on a vector of aggregate shocks η_t, i.e.:

$$p_t^k = p^k(t,\ \eta_t)$$

where η_t is a subset of ε_t.

Maximizing the weighted sum of individual discounted utilities subject to a group-level budget constraint yields a Pareto efficient allocation. Let ω_i stand for an arbitrary set of welfare weights. Partition the shocks ε_t into aggregate shocks η_t and idiosyncratic shocks ϕ_t conditional on η_t; by construction, $Prob(\varepsilon_t) = Prob(\eta_t)\, Prob(\phi_t\,|\,\eta_t)$.[33] All group-level Pareto efficient allocations can be found by varying the welfare weights ω_i in the following program:

$$Max\ \ \sum_i \omega_i \sum_t \beta^t \sum_\eta Prob(\eta_t) \sum_\phi Prob(\phi_t\,|\,\eta_t) U^i(c_t^i,\ l_t^i)$$

subject to

$$\sum_i [p_t^q(\eta_t)c_t^i + p_t^b(\eta_t)b_t^i + p_t^a(\eta_t)a_t^i] = \qquad \text{(budget constraint)}$$

$$p_t^q(\eta_t)\overline{q}_t(\eta_t) + (1-\delta)\overline{s}_t(\eta_t) - s_{t+1} + \sum_i p_t^a(\eta_t)(T_t^i - l_t^i) +$$

$$p_t^M \sum_i [(1+r^l)L_t^i - L_{t+1}^i + M_t^i - M_{t+1}^i]$$

where $\overline{q}_t(\eta_t) \equiv \sum_i q_t^i(\varepsilon_t)$ denotes total group output and $\overline{s}_t(\eta_t) \equiv \sum_i s_t^i g^i(\varepsilon_t)$ denotes total grain stocks. It immediately follows from the budget constraint that money is a dominated asset and that it should not be used as a savings instrument.

Associate Lagrange multiplier λ_t with each budget constraint and Lagrange multipler θ_t with each the credit constraint.

Pareto efficiency and hence efficient risk sharing requires that:

$$\omega^i \beta^t Prob(\varepsilon_t) U_c^i(c_t^i(\varepsilon_t),\ l_t^i(\varepsilon_t)) = \lambda_t(\varepsilon_t) p_t^q(\eta_t) \tag{40}$$

$$\omega^i \beta^t Prob(\varepsilon_t) U_l^i(c_t^i(\varepsilon_t),\ l_t^i(\varepsilon_t)) = \lambda_t(\varepsilon_t) p_t^l(\eta_t) \tag{41}$$

Since the budget constraint and credit constraints are the same for all the possible realizations of ϕ_t's that correspond to a particular realization of η_t, it is easy to verify that the $\lambda(\eta_{t)}$ satisfies:

$$\lambda(\varepsilon_t) = Prob(\phi_t\ |\ \eta_t)\lambda(\eta_t)$$

[33] To keep the notation simple, we assume that the distribution of shocks is i.i.d. over time. It can be shown that results are unchanged if shocks are correlated over time.

As a result, the conditions for Pareto efficiency can be rewritten:

$$\omega^i \beta^t Prob(\eta_t) U_c^i(c_t^i(\varepsilon_t \mid \eta_t),\ l_t^i(\varepsilon_t \mid \eta_t)) = \lambda_t(\eta_t) p_t^q(\eta_t) \tag{42}$$

$$\omega^i \beta^t Prob(\eta_t) U_l^i(c_t^i(\varepsilon_t \mid \eta_t),\ l_t^i(\varepsilon_t \mid \eta_t)) = \lambda_t(\eta_t) p_t^l(\eta_t) \tag{43}$$

for all $\varepsilon_t \mid \eta_t$. Equations (42) and (43) establish that, if risk is shared efficiently within the group, individual consumption is only function of aggregate shocks η_t.

By the same reasoning, it follows that production choices depend only on aggregate risk:

$$\lambda(\eta_t)\, p_t^b(\eta_t) = \sum_{\eta} Prob(\eta_{t+1})\, \lambda(\eta_{t+1})\, p_{t+1}^q(\eta_{t+1}) \frac{\partial\, q_{t+1}^i(\eta_{t+1})}{\partial\, b_t^i} \tag{44}$$

for all b_t^i. The less concave, i.e., the flatter $\lambda(\eta_{t+1})$ is as a function of η_{t+1}, the more individual production choices ressemble those made by a risk neutral agent maximizing expected profit. Efficient risk sharing among members of the group thus enables agents to take more risk in crop production and, by extension, in any risk-taking enterprise.

There are various ways by which efficient allocations can be supported. One approach is to integrate the group into a single entity that pools resources and solves the above social welfare problem. Efficiency can also be supported through markets for credit and insurance.

3.3 Households and groups

Perhaps the most universal institution for pooling resources and sharing risk is the household (e.g., Dercon and Krishnan (1997)). After all, one of the major motives behind household formation even in developed societies is to provide care and nurturing for the most defenceless among us: children. As all parents know, children are prone to disease and accidents and they require more or less constant attention. Single parents usually find it taxing to combine a job, let alone a carreer, with responsible parenting. Sharing child care with others by forming a household is the preferred method for raising children the world over. When child care is particularly time consuming, for instance because kids are many, it may even be optimal for one household member to specialize in parenting and to rely on other household members for sustenance (e.g., Becker (1981)). This typically results in gender-casting, that is, on sets of social norms and ethical values that emphasize the special responsability of women as mothers. In poor rural communities, households are also the institution within which care is taken of the sick, the disabled, and the old. Retirement homes, mental institutions, and convalescence clinics are unheard of. It is within the household that people find solace when they are hit by disease and where they seek moral support when bad luck strikes.

Given the importance of households in the sharing of risk, it is not surprising that poor rural societies put a lot of emphasis on household formation in their ethical values and social practices. As anthropologists have documented in all human societies, the creation and dissolution of households are important social events that call for well attended rituals (e.g., birth, marriage, death). Much of family law, whether traditional or modern, can be seen as an effort to ensure that household members have a strong interest in preserving the stability of the household and in working as a team to handle shocks. In many societies, this is accomplished by providing incentives for women to specialize in taking care of vulnerable members of the household -- for instance by making it difficult or impossible for women to work outside the home (e.g., Fafchamps (1998), Fafchamps and Quisumbing (1998)). One may object to such practices on the ground that they are both inefficient and inequitable: by denying women the freedom to express their full economic potential, gender casting prevents an optimal allocation of individual talents among alternative activities. The fact remains that many societies choose to forego these allocative efficiency gains and prefer to emphasize gender casting instead. One possible explanation is that these societies attach a lot of importance to risk sharing and seek to protect those in need of assistance by casting women in the role of mothers and care givers and by nurturing among women values that emphasize compassion for children, the weak, the sick, and the old.

Legal or customary rules governing the devolution of assets upon household dissolution can similarly be seen as an effort to provide for its most vulnerable members, i.e., children and, to a lesser extent, wives.[34] In developed urban societies, these concerns are expressed in the form of child care and alimony payments following divorce, for instance. Poor rural societies often have similar concerns, but express them differently. Since very few people receive regular wages from long term employment, the payment of fixed regular transfers is highly impractical. They are replaced by endowments of land or livestock that serve as a source of income through self-employment or, occasionally, through the rental of factors of production. In some cases, human capital investment replaces transfers of physical capital, as shown for instance by Quisumbing (1997) in the Philippines.

Given the importance of households in the explicit sharing of risk, it is not surprising to discover that the size and composition of households partly reflects the risk environment surrounding them. As Binswanger and McIntire (1987) pointed out, it is common for households in poor rural areas to span several generations and to include several nuclear households, i.e., several sets of parents with their children. Combined with high fertility rates, this implies that households in poor rural areas are often large -- e.g., from five to eight members on average. It is not uncommon to encounter households with as many as thirty or more members; in contrast, single households are rare. The structure and organization of these large households can be quite complex and each member or nuclear unit is often granted quite a bit of autonomy in managing their own affairs provided their fulfill their obligations to the common good of the household (e.g., von Braun and Webb (1989)). While a detailed discussion of the internal organization of large rural households is beyond the scope of this study, certain features deserve to be mentioned. First, large households often keep a single kitchen.[35] This enables them to capture returns to scale in food preparation but also ensures that food is shared among all members. Second, large household normally keep a single granary, implying the sharing of yield risk among members. Third, members take care of each other in bad times: the sick, the disabled and the old are looked after, and the unemployed are provided with food and shelter. Finally, even though members of large households often manage certain activities individually, institutional mechanisms are present that ensure the pooling of labor resources for vital household chores such as food production. One such mechanism is the head of household's power to call upon each household member to contribute labor to the common field (e.g., von Braun and Webb (1989)).[36] All these features point toward the role of households as risk sharing institutions.

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[34] The fact that, in many societies, wives are perceived as economically vulnerable is largely a consequence of gender casting: encouraging women to specialize in the provision of care within the household implies that they develop skills that have little market value (e.g., Becker (1981)). To ensure that women find the provision of household care in their long-term interest, they need to be compensated for specializing in non-market skills when the household break down.

[35] In fact, 'eating from the same pot' is the most commonly used defining feature of a household unit.

[36] The allocation of labor within the household can lead to conflicts of interest among members and result in inefficiencies; see for instance Udry (1996), Jones (1986).

The paramount role of households in risk sharing can also be seen *in absentia* by noting that the poorest members of society often are isolated individuals: old men and women with nobody to look after them, runaway children, physically or mentally disabled individuals who have been discarded by their family, etc. Poverty is often associated with dysfunctional families and household separation generally leads to a lowering of standards of living. This occurs in part because returns to scale in the provision of common household goods (a home, a car, a kitchen) are lost, but also because the reduction in risk sharing opportunities forces a less efficient allocation of resources.

Explicit pooling of resources may also take place, albeit in a weaker form, within larger groups. For instance, common property resources are often used partly as an asset upon which community members may draw in case of need. Swidden cultivation in East and South-East Asia, for instance, often serves as source of food when the main rice harvest fails. Wild grains and roots similarly serve as foods of last resort.

3.4 Explicit insurance

Short of pooling resources, individuals may also pool risk explicitly through mutual insurance contracts. One form that such insurance contracts may take is that of contingent claims and obligations. For instance, suppose that in state of the world s_1, Jack has 200 kg of rice while Jill has none. Assume that Pareto efficiency requires that both consume 100 kg. A mutual insurance contract simply stipulates that when Jack has 200 kg of rice when Jill has not, Jack gives 100 kg of rice to Jill. Similarly, in state of the world s_2 when Jack has nothing when Jill has a lot, Jill gives something to Jack. Promises by Jack and Jill to give each other rice in states of the world s_1 and s_2 can theoretically be traded between Jack and Jill at the beginning of time, in which case they formally ressemble what general equilibrium theory calls Arrow-Debreu securities. Alternatively, Jack and Jill may agree upon a mutual insurance contract that stipulates the quantities to be given by one to the other in each state of the world. The same idea can be extended to an arbitrary number of members.

One problem with the kind of mutual insurance schemes described above is the difficulty of stipulating beforehand the obligations of each member in each state of the world. When the group is very large and idiosyncratic shocks are not correlated, aggregate shocks may be so small as to be ignored. In this case, a simple contract can be written that stipulates a flat and constant fee, and compensation rules that are constant over time and depend only on individual shocks. In case shocks are moderately correlated or if the group is not large, aggregate shocks do not vanish. One possibility is to make the payout rate of the mutual insurance scheme contingent on aggregate resources, but this is likely to complicate the contract. Another, simpler approach is to endow the mutual insurance scheme with an initial amount of money sufficient to ensure that the scheme does not run out of money.[37] Many social welfare programs in developed economies closely approximate this kind of mutual insurance contracts: health and unemployment insurance, uncapitalized pension schemes, etc. In fact, many of these programs were initially organized as voluntary mutual insurance funds.

Some examples of explicit mutual insurance contracts and institutions can be found in poor rural societies. For instance, it is not uncommon for Sahelian villages to cultivate certain fields in common and use the harvest as a village welfare fund administered by the chief. The explicit pooling of risk is also very common among groups of fishermen (e.g., Platteau, Murickan and Delbar (1985), Platteau and Abraham (1987)). Sahelian farmers often form

[37] Or, at least, nearly never.

groups of three or four individuals who pool their labor resources and jointly cultivate each other's fields. In this fashion, if one of them is sick or must absent himself from work, the others can take care of his fields. Many African rural communities also have institutions whereby sick farmers can call upon others to come and harvest their farm (e.g., Fafchamps (1992)). Although these explicit risk sharing arrangements and institutions have been documented in a variety of societies and environments, they appear to be both fairly infrequent and diminishing in importance over time. Does this mean that explicit risk sharing across households is absent? Not necessarily.

Other mechanisms indeed exist that can also, at least theoretically, support Pareto efficiency. One possibility is to organize a spot market for contingent claims among village members. Let $R(\varepsilon_{t+1})$ denote a payment of R units of the numeraire if state of the world ε is realized at time $t+1$. Suppose that promises to pay $R(\varepsilon_{t+1})$ are perfectly and costlessly enforceable and that they are traded in a competitive market among village members. Consequently, the price at which promises are traded at time t only reflects current and future aggregate conditions. Formally, denote the price of a promise of one unit of numeraire in state of the world η_{t+1} by $p(\eta_t, \eta_{t+1})$. Rank states of the world such that low η_t correspond to low aggregate endowments, and high η_t to high aggregate endowments. Using equations (42) and (43), and the Euler equation of from an individual capable of buying and selling promises, it can be shown that their price must be such that (e.g., Townsend (1993), Udry (1992)):

$$p(\eta_t, \eta_{t+1}) = Prob(\eta_t)\, \frac{\lambda(\eta_{t+1})\, p^q_{t+1}(\eta_{t+1})}{\lambda(\eta_t)\, p^q_{t+1}(\eta_t)} \tag{45}$$

λ_t denotes the marginal utility of consumption weighted over all group members. To the extent that individuals are risk averse, that grain storage is costly, and that the group is subject to aggregate shocks, λ_t is decreasing in η_t. From equation (45), we then see that, if there is currently a lot of grain in the economy, and thus $\lambda(\eta_t)$ is low, a promise of giving grain tomorrow can be exchanged for a lot of grain today: p is increasing in η_t. Similarly, a promise of giving grain in a bad aggregate state of the world tomorrow can be exchanged for a lot of grain today: when η_{t+1} is low, convexity of the utility function implies that $\lambda(\eta_{t+1})$ is high, and thus that p is decreasing in η_{t+1}.

The usefulness of the above construction comes from the fact that contingent promises can be bundled together into what can be referred as credit contracts with state-contingent repayment (e.g., Townsend (1993), Udry (1992)). To see why, define lending B_t as the price paid for an entire bundle of contingent repayment promises:

$$B^{i_t} = \sum_{\eta_{t+1}} Prob(\eta_{t+1})\, p(\eta_t, \eta_{t+1}) \sum_{\phi_{t+1}} Prob(\phi_{t+1} \mid \eta_{t+1}) R^i(\eta_{t+1}, \phi_{t+1}) \tag{46}$$

Equation (46) indicates that the rate of interest on a promise to pay one unit of grain in all states of the world is equal to $\dfrac{1}{\sum_{\eta_{t+1}} p(\eta_t, \eta_{t+1})}$; it is increasing in η_t and decreasing in η_{t+1}. Full insurance of idiosyncratic risk follows from equation (46). To see why, suppose that, given η_{t+1}, there are only two possible realizations, one good for i and one bad for i, each of which has equal probability. From equation (46), it is clear that a promise to pay one unit of grain in states $\phi_{t+1} \mid \eta_{t+1}$ sells for the same price as a promise to pay two units of grain only in the good state for i: price p depends only on η_{t+1}, not on ϕ_{t+1}. Since any risk averse individual would prefer the second option to the first, it is clear that optimal contingent credit repayment of this kind can serve to efficiently pool idiosyncratic risk.

Evidence in favor of the contingent credit hypothesis can be found in the works of Udry (1990), Udry (1994), Townsend (1995), Platteau and Abraham (1987), and Fafchamps and Lund (1999). Other studies such as that by Rosenzweig (1988), Christensen (1987) further confirm that credit among villagers in poor rural communities plays an important insurance role. Contingent informal credit can also be found among urban entrepreneurs (e.g., Fafchamps, Pender and Robinson (1995), Fafchamps et al. (1994)). Several characteristics of informal credit contracts do not, however, appear consistent with the hypothesis of perfect markets for contingent contracts. For one thing, the documented magnitude of the effect of contingencies on debt repayment appears too small relative to the risks faced by debtor and creditor. Second, informal credit contracts often stipulate zero interest, irrespective of current conditions. This feature is in contradiction with the predicted dependence of expected interest on η_t. Finally, access to contingent credit appears restricted, a feature inconsistent with the assumed market clearing property of contingent prices $p(\eta_t, \eta_{t+1})$. We shall revisit these issues in the next chapter.

3.5 Interlinking and patronage

The weaving of insurance-type provisions into other contracts is another form of risk sharing that has attracted a lot of attention in the development economics literature. Contingent credit, which we just discussed, is but one example of such interlinking. Since Stiglitz's (1974) seminal article on sharecropping as a risk sharing device, the theoretical literature on land and labor markets has explored these issues in great detail (e.g., Braverman and Stiglitz (1982), Bardhan (1984), Datta et al. (1988), Bell (1988)). Much of this literature follows from the same simple observation. Suppose two agents enter into a contractual arrangement in which one set of contractual obligations is delayed. Examples of such contracts include not only lending and borrowing but also land rentals, labor contracts, forward sale of agricultural output, supplier credit, and warranty provisions. In addition, suppose that one party to the contract is more risk averse than the other and that perfect insurance is not available through any other source. It is then in the interest of the parties to incorporate an element of risk sharing into their contract. Since the risk averse party is willing to pay for insurance, the risk neutral party can raise the expected price of the product or service they offer by sharing risk with the other party. Although much of the literature on interlinking assumes some amount of asymmetric information, the rationale for including risk sharing provisions into other transactions does not require it. The role of asymmetric information is rather to explain why parties would choose to share risk in an inefficient manner, e.g., through sharecropping instead of insurance.

There is only weak evidence in favor of interlinking as an explicit risk sharing device used in poor rural areas. Empirical studies of sharecropping, for instance, suggest that sharecropping is efficient (e.g., Sadoulet, Fukui and de Janvry (1994)). This result is in contradiction with models in which sharing crop output is a way of trading off inefficient insurance against inefficient effort (e.g., Stiglitz (1974)). Evidence of explicit interlinking of insurance with other contracts is even more tenuous. In constrast, explicit interlinking it has been documented in urban areas. Fafchamps (1996), Fafchamps et al. (1994), Fafchamps, Pender and Robinson (1995), for instance, provide ample evidence of interlinking of commodity sales and credit among African manufacturers. Contractual performance in manufacturing contracts is often contingent upon shocks affecting the parties (e.g., Lorenz (1988), Fafchamps (1996)). In developed economies, explicit interlinking appears even more common. For example, most manufacturers, retailers, and even credit card companies offer extended warranty on consumer items; supplier credit is the norm in relations between firms and also, thanks to credit cards, between firms and consumers; and labor contracts of managers and even workers customarily include participation in the firm's profits. If anything, explicit interlinking appears less common in developing than in developed countries and in rural than in urban areas.

One possible explanation is that, in poor rural areas, explicit interlinking is replaced by long-term patronage relationships. Patronage is defined as a situation in which a wealthier member of the village provides factors of production and/or insurance to poorer villagers in exchange for a regular stream of miscellaneous services, mostly labor (e.g., Platteau (1995a, 1995b)). The long-term multifaceted relationship that bonds a patron to his or her clients enable parties to condition actions in one aspect of their relationship upon the other party's action in another aspect -- what Basu (1986) calls triadic relations. Although the spirit of the resulting interaction ressembles that of interlinking, each transaction between the parties need not contain any explicit insurance. Rather, it is often the continuation of the relationship itself -- and the access to credit and factors of production that it guarantees -- that constitutes risk sharing.

One extreme version of patronage is labor bonding, discussed earlier. Another example is debt peonage (e.g., de Janvry (1981), Geertz (1963), Crow and Murshid (1990)); it works a follows. An individual in difficulty borrows from a wealthier member of the community -- e.g., a landlord, moneylender, or merchant. If all goes well, the debt is repaid and the debtor is off the hook. If the debt cannot be repaid, repayment is postponed but interest keeps accruing, possibly compounded by late interest charges. Comes a time when the nominal amount of the debt exceeds what the debtor can ever hope to repay. The debtor then becomes what is called a debt peon.[38] Formally, let $\underline{U}$ represent the expected utility to which the creditor can credibly keep a defaulting debtor. The creditor can force the debtor to accept any repayment that satisfies:

$$U(\pi_t - b_t - R_t) \geq \overline{U} \tag{47}$$

where π_t is the debtor's current cash-in-hand and b_t stands for unanticipated consumption needs, such as illness and ritual shocks. Equation (47) indicates that, as long as the utility of the debtor after repayment does not fall below $\underline{U}$, voluntary repayment of R_t is in his or her interest. Since $U'(.)$ is positive, equation (47) also implies that R_t is increasing in $\pi_t - b_t$. Consequently, since $\pi_t - b_t$ depends on the shocks affecting the debtor, it is in the interest of the creditor to modulate repayment R_t according to the current situation of the debtor. The repayment rule that maximizes total discounted repayment $\sum_{t=0}^{\infty} R_t$ is one in which $R_t = \pi_t - b_t - \underline{R}$ where $\underline{R}$ is such that:

$$U(\underline{R}) = \overline{U} \quad or \quad \underline{R} = U^{-1}(\overline{U}) \tag{48}$$

As long as the creditor is (approximatively) risk neutral and maximizes expected discounted repayments, it is optimal for him or her to perfectly smooth the debtor's welfare. Debt peonage is thus a form of insurance.[39] Under certain circumstances, it may even be optimal for the creditor to provide net flows of funds to a debt peon -- i.e., to extend new loans --

[38] The exact meaning of the spanish term 'peon' appears to lie somewhat between that of 'peasant' and

[39] Formal models of debt peonage as described here can be found in the literature on sovereign debt, e.g., Eaton and Gersovitz (1981), Kletzer (1984), Grossman and Van Huyck (1988).

when $\pi_t - b_t$ is particularly low. To see why, suppose that $\overline{U}$ is the welfare level that barely guarantees survival of the debtor and his or her family. If welfare falls below U, the debtor disappears. Provided that $\sum_{t=1}^{\infty} R_t > 0$, it is then in the interest to keep the debtor alive by easing the debtor's temporary difficulties and raising his or her welfare to $\overline{U}$.

Equation (48) indicates that R decreases with decreasing in $\overline{U}$: the more the creditor can punish the debtor, the higher repayment is. In practice, the level of $\overline{U}$ depends on the creditor's capacity to foreclose on the debtor's meager assets,[40] to ban the debtor from employment on the creditor's farm or business, or to prohibit the debtor from purchasing goods from the creditor's store. To be effective, these threats must be credible, that is, punishment must be in the *ex post* interest of the creditor. Punishments such as a ban from employment on the creditor's farm or from purchase from the creditor's shop may not satisfy this requirement: after all, it in against an employer's interest to refuse workers (this may raise wages or search costs for other workers) and against a shopkeeper's interest to turn down customers (this is likely to reduce profits). Even if punishment is *ex post* costly for the creditor, however, it may still be in his or her interest to punish a faulty debtor if this serves to maintain a reputation for toughness and thus helps discipline other debtors (see Kreps et al. (1982) for a formalization of this idea). By the same reasoning, a creditor with numerous debtors may further lower their $\overline{U}$ by hiring thugs and using strong-armed tactics (e.g., Crow and Murshid (1990)).

In order to for debt peonage to persist over time, the nominal value of the debt D_t must be sufficiently high to ensure that what is owed to the creditor always exceeds $\pi_t - b_t - U^{-1}(\overline{U})$, i.e., that:

$$D_t \geq Sup\{\pi_t(s_t) - b_t(s_t) - U^{-1}(\overline{U})\} \equiv \overline{D} \tag{49}$$

If equation (49) is not satisfied at all t, the debt will eventually be repaid with probability one.[41] Since $\pi_t - b_t$ is stochastic, equation (49) implies that nominal debt is higher than expected repayment, i.e., $D_t > E_{t-1}[R_t]$.[42] The fastest way for creditors to raise D_t above $\overline{D}$ is by charging a high interest rate and, if possible, late payment charges and fees. Once D_t has been raised above $\overline{D}$, the creditor can credibly extract all the surplus above $\overline{U}$ without further raising D_t; once permanent debt peonage is achieved, the creditor may even afford the luxury of appearing magnanimous by forgiving the part of the debt that exceeds $\overline{D}$.

As is clear from the above, allowing usury in an environment characterized by widespread poverty and risk is bound to lead to debt peonage and thus the virtual enslavement of many. Societies may be fearful of the social tensions and resentment thus created and may seek to avoid the polarization of society implied by debt peonage. The historical prohibition of usury both by the catholic church and Islam should probably be interpreted in this light. Such prohibitions, however, are inherently difficult to enforce. To see why, note that the maximum amount R that an individual can borrow is an increasing function of the nominal interest rate r charged by the creditor -- at least up to the point where $(1+r)R = \overline{D}$. For any

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[41] This results from the law of martingales.

[42] The situation in which the nominal amount of the debt does not represent what creditors expects to receive formally ressembles what, in the sovereign debt literature, is called debt overhang. Data on secondary markets for sovereign debt provide ample evidence of discrepancy between the face value of a debt and its valuation by creditors (e.g., Cohen (1990), Kyle and Sachs (1984)). See Fafchamps (1996) for a detailed discussion of the determinants of this discrepancy.

interest rate $r < \bar{D}/\bar{R} - 1$, expected repayment is below $\bar{D}$: there are some advantageous states of nature under which the debtor does not repay all the difference between $\pi_t - b_t$ and $\underline{R}$. Let the function $R(r)$ denote this relationship, with $R(r) \leq \bar{R}$.

Now suppose that an individual is faced with a large shock such that $U(\pi_t - b_t) < \bar{U}$: his or her survival is a stake. Let r_n denote the socially acceptable (non usury) rate of interest. If:

$$U(\pi_t - b_t + R(r_n)) < \bar{U} \tag{50}$$

but

$$U(\pi_t - b_t + \bar{R}) \geq \bar{U} \tag{51}$$

the individual will voluntarily accept a usurious loan contract. In this case, debtors willingly borrow at usurious interest rates and the socially acceptable rate of interest cannot be enforced. This examples illustrates that the prohibition of usury must be accompanied by social insurance programs to be viable.

3.6 Sharing risk across village boundaries

So far we have discussed arrangements by which risk can be explicitly shared within the boundaries of the rural community. There also exist institutions that enable villagers to share risk with the rest of the world. One such strategy is seek the patronage of village residents who are connected to the rest of the world, such as merchants, aristocrats, or civil servants temporarily posted in the village. Udry (1990), for instance, points out that much quasi-credit in the villages he studied in Northern Nigeria is given out by Hausa merchants who use their outside contacts to raise funds. Similar mechanisms are described in Watts (1983) and Crow and Murshid (1990). These individuals can then be seen as intermediaries in the sharing of risk across village boundaries. The provision of such risk intermediation services can be a important source of social clout and political power.

Another strategy to share risk over space is simply to send village members away and ask them to help support their friends and relatives who remain in the village. Temporary and permanent labor migrations out of poor rural areas of the Third World are an extremely common and persistent phenomenon. Migrant workers go mostly to cities, mines, and plantations. Some of them move across international boundaries as well. Discussing labor migrations in detail is beyond the scope of this report but it is important to acknowledge that, in many poor rural communities, remittances from migrant workers constitute an essential part of rural incomes (e.g., Alderman and Garcia (1993), Adams and He (1995), Stark and Lucas (1988), Lucas and Stark (1985)). Rosenzweig and Stark (1989) have argued that marriages follow a pattern similar to that of labor migrations and that the geographical matching of brides and grooms is partly motivated by income diversification motives.

Whether remittances explicitly serve the role of insurance remains an unresolved issue. Although in some cases remittances respond to shocks affecting the recipient family (e.g., Lucas and Stark (1985)), in other cases they do not (e.g., Fafchamps and Lund (1999)). Whether or not remittances are modulated in response to shocks should not, however, distract from the fact that remittance transfers are often essential to the survival of the recipient family. Given the cost of communicating with migrants and the difficulties and risks of transfering money across space in most Third World countries, it may be more efficient for recipients to leave the timing of remittances to the discretion of migrants and to invest at least part of the remittance money in precautionary forms of saving (e.g., Alderman and Garcia (1993)). Pensions paid to retired workers, soldiers, and war veterans belong essentially to the same category as remittances, except that they are delayed wage payments that may last long after the migrant has returned to the village. In South Africa, survival in many of the former so-called bantoustans revolved primarily around remittances and pensions.

The provision of modern health services is another important form of insurance that typically involves risk sharing across village boundaries. By itself, the delivery of modern medical services to rural areas is a form of insurance since it reduces fluctuations in welfare. To see why, let utility be written $U(\pi_t, h_t)$ where π_t is monetary income and h_t is the health status of the household, itself function of random health shocks. Normalize h_t such that 0 stands for good health. Define $b(h_t)$ as the equivalent variation associated with health status h_t, i.e.,:

$$U(\pi_t - b(h_t), 0) \equiv U(\pi_t, h_t) \tag{52}$$

Function $b(h_t)$ represents the household's willingness to pay to avoid imperfect health h_t.

Suppose that, thanks to technological innovation in medecine, the health status of the household can be protected at cost $c(h_t)$. If $c(h_t) < b(h_t)$, it is in the interest of the household to incur the health cost and preserve its good health status. We have:

$$U(\pi_t, 0) \geq U(\pi_t - c(h_t), 0) > U(\pi_t, h_t) \tag{53}$$

Equation (53) shows that purchasing the health service raises the household's utility and reduces the incidence of health risk on its welfare. *A contrario,* if $c(h_t) > b(h_t)$, the cost of the cure is too high to justify the expense. On average, therefore, we have:

$$EU(\pi_t - Min[c(h_t), b(h_t)]) \geq EU(\pi_t - b(h_t)) \tag{54}$$

Voluntary purchase of health services raises welfare by reducing the incidence of health risk. Together with equation (53), equation (54) indicates that the reduction in the effect of health risk on welfare achieved via health services is a decreasing function of health cost $c(h_t)$. At the limit, if health cost is 0 for all h_t, then expected utility is $EU(pi_t, 0)$: health risk is eliminated.

In many countries, the provision of modern health services often seek to provide health cost insurance and to redistribute welfare in addition to the health service itself. Health cost insurance can easily be added to our framework as follows. Consider a full coverage insurance scheme and let m be a constant premium such that the health insurance scheme breaks even on average, i.e., such that $m = Ec(h_t)$. Clearly:

$$EU(\pi_t - m, 0) \geq EU(\pi_t - c(h_t), 0) \tag{55}$$

with strict inequality if the function U is concave, i.e., if the household is risk averse. Health cost insurance raises welfare. In practice, it may not be optimal -- or even feasible -- to eliminate health risk altogether. Among poor rural populations, expensive treatments such as AZT, cat scans, and the like are seldom cost effective in the sense that $c(h_t) > b(h_t)$. Given the choice among various insurance contracts, the rural poor are therefore likely to opt for cheaper plans that do not cover expensive treatments. These concerns are reflected in the health cost insurance plans put in place in many developing countries (e.g., Gertler, Locay and Sanderson (1987)): instead of the uncapped health insurance plans with deductibles that are encountered in most developed countries, many poor countries have opted for insurance schemes that fully pay for health care up to a certain amount, beyond which coverage stops. This approach can be a cost-effective way of providing health insurance to the poor.

Health insurance schemes often include a redistributive dimension as well, in the sense that the premium paid by some individuals i is smaller than their anticipated use of the service, i.e., that $m_i < Ec(h_{i,t})$. Of course, to break even, a redistributive scheme must collect higher premia from other individuals. In practice, evaluating the redistributive effect of health insurance schemes is complicated by the fact that many public schemes are financed by taxes, and that effective redistribution depends on the geographical distribution of health facilities and on the allocation of public funds among different types of health services (e.g., Gertler and Strum (1997)). These issues are beyond the scope of this study.

Another important form of insurance available to poor rural communities is assistance from national governments and the international community. National relief organizations and NGO's have long sought to minimize the incidence of catastrophic risk such as earthquakes, hurricanes, avalanches, floods, droughts, locusts, and refugee crises. International assistance is also often provided to help governments deal with particularly accute crises -- or to substitute for governments when their action in impeded by warfare or lack of funds. Prevention and protection against certain aspects of catastrophic risk are part of the mandates of several United Nations agencies, such as the UNHCR and the FAO.

However important these organizations are, evidence suggests that their effect on target populations remains small and that assistance does not always reach the neediest. For instance, Reardon, Matlon and Delgado (1988), Reardon, Delgado and Matlon (1992) show that during the 1984 drought in Burkina Faso, international aid accounted for a very small proportion of the total transfers received by surveyed households. Furthermore, the geographical distribution of aid did not correspond to the welfare incidence of the drought: of six surveyed villages, the two that were worst hit received less aid than two others which were less affected. The difficulties inherent in identifying households most in need of assistance are further compounded by logistical problems. Delivering international aid to those in need is indeed often problematic because local infrastructures are not geated up to chanelling large amounts of food to remote rural areas. Delivery can also be hindered by warfare and complicated by erratic movements of refugee populations. These problems are well known and need not be discussed in detail here.

Section 4. Allocation of Scarce Resources Within the Household

Whenever the risk-coping strategies discussed thus far do not shelter households from the effect of risk, unpleasant choices must be made regarding the allocation of scarce resources among household members. These choices are but a reflection of the absence of better options.

4.1 Extreme deprivation and selective mortality

When resources are extremely scarce in the sense that the survival of all household members cannot be achieved, equitable division of resources among members is inefficient. To see why, suppose that the resources π_t of a household with M members are smaller than $M\,\underline{c}$ where $\underline{c}$ is the minimum level of consumption to ensure survival. Equal distribution of resources means that all members would starve, since $\frac{\pi_t}{M} < \underline{c}$. In this case, it is clearly optimal to concentrate the available resources on certain members. As a result, one would expect mortality to be selective whenever households are subject to extreme deprivation.

Efficiency further dictates that the members of the household selected for survival should be those whose income generating potential is highest. Doing so maximizes the chances that, once the crisis that led to extreme deprivation is over, the household will be able to sustain itself. Straight application of this principle implies higher mortality among those that are otherwise unable to feed or provide for themselves. For instance, it makes little sense for a famine-striken family to feed small children and starve adults: surviving small children could not taken care of themselves once their parents are dead. By the same token, the sick, the elderly, and the disabled are low priorities for survival if resources are extremely scarce. These cruel principles are largely in line with evidence of higher mortality among young children and old people during famines (e.g., Sen (1981)). These harsh realities often leave their mark on culture and tradition.[43]

4.2 Gender and nutrition gap

Efficiency considerations may similarly dictate an allocation of scarce nutrition and health resources that favors certain members of the household. For instance, it is customary in many rural societies for male adults to eat first.[44] Nutrition data similarly suggest the widespread existence of a nutrition gap in favor of males among poor communities (e.g., Strauss and al. (1993)). More recently, Dercon and Krishnan (1997) show that anthropological data from rural Ethiopia are inconsistent with perfect risk sharing among household members.

One possible interpretation for the priority given to adult males is that it reflects the traditional dichotomy between the productive roles of men and the reproductive roles of women. Suppose children are regarded by poor households as investments in the future. The reproductive role of women implies that female nutrition is an input in the production of children: better fed women are more likely to have healthy babies and to breastfeed them effectively (e.g., Thomas, Strauss and Henriques (1990)). Negative income shocks lower the household’s willingness to invest, and hence the need to invest in female nutrition. A similar result is obtained if, at extremely low levels of income, children are regarded as luxury consumption goods. In both cases, very low entitlements result in neglected child nutrition and health and a simultaneous decrease in female nutrition.

4.3 School drop-outs

If low incomes can lead households to neglect child nutrition, then certainly it can induce them to withdraw kids from school in hard times. Jacoby and Skoufias (1995) and, more recently, Sawada (1997) have shown that rural households are more likely to withdraw children from school not only when they are chronically poor but also when they are hit by a negative transitory income shock. The effect is particularly marked for girls. They are similarly less likely to enroll children in school. The magnitude of the transitory income shock effect is inconsistent with the certainty equivalence model, suggesting that households withdraw children from school because they are unable to smooth shocks by liquidating assets or borrowing from other villagers. Imperfect insurance thus lowers investment in human capital and has effects on long-term income distribution and on a country’s capacity to innovate and modernize. These issues are revisited in Chapter IV.

[43] In Ethiopia, for instance, it is customary not to name a child until it has attained two years of age.

[44] This is true, for instance, in Northern Ethiopia where children eat after their parents. Not so long ago, in much of rural Europe the head of the household would be served first and other members next; the wife would serve the meal and eat later.

CHAPTER III. THE LIMITS TO RISK COPING

We have reviewed in great detail a variety of individual and collective strategies on which poor rural households rely to cope with risk. These strategies do not always work, however. In this chapter we examine some of the factors that render particular strategies ineffective. Evidence regarding the most serious constraints is also discussed.

Section 1. The Limits to Self-Protection

1.1 Technological and environmental constraints

Technological and environmental constraints put limits on households' ability to reduce their exposure to risk. Income diversification may be impractical either because returns to alternative activities are too low to warrant investing in them, or because increasing returns call for specialization. Millet in the Sahel is a good example of a case in which environmental constraints limit the options open to rural households. After centuries of informal breeding by Sahelian farmers, millet has developed into an incredibly sturdy plant capable of growing extremely fast on precious little moisture and soil nutrients. Thanks to millet, African farmers have pushed the limits of cultivation further into the Sahara desert than was thought possible. The corollary of this success, however, is that no other plant can compete with millet, let alone beat it. As a result, the monoculture of millet is the norm in much of the Sahel (e.g., Matlon and Fafchamps (1989)). Similar reasoning explains why drought or trypanosiomiasis resistant livestock breeds are the only ones encountered in drought or trypanosiomiasis-prone areas.

Pastoralism is a good illustration of a situation in which income diversification is traded off for returns to specialization. Pastoralism refers to specialized livestock raising based on long-range migrations of animals and herders. It is encountered in many semi-arid areas of the world (e.g., Sandford (1983), Monod (1975), Nugent and Sanchez (1989), Nugent and Sanchez (1990)). Erratic rainfall both over time and over space means that animals must be moved over extremely large areas for livestock production to be feasible, let alone profitable. The need to be constantly on the move precludes most other activities or, at least, renders them costly. In practice, the thirst for income diversification is often so compelling that many pastoralists engage in some form of cultivation in spite of the high costs involved, namely, the separation of families over long periods of time (e.g., Sandford (1983), Monod (1975)).

Flexibility is another risk reducing strategy that is subject to technological and environmental limitations. For instance, to grow grain, seeds must be planted. Once planted, they can no longer be eaten, even if rains fail and yield is zero. The extent to which precious resources must be sunk before income can be generated limits households' willingness to risk these resources. This issue is formalized in Fafchamps (1993) who shows that flexibility is lowest in dry areas because of the extremely short nature of the rainy season precludes crop diversification and reduces the scope for replanting. Such concerns often are behind farmers' reluctance to adopt technologies and crop varieties that lock them into strict patterns and limit their capacity to adjust to shocks as they unfold.

By the same token, activities that require a large up-front investment reduce households' capacity to deal with shocks *ex post* through asset liquidation, even though they may reduce risk itself. This issue is examined in detail by Fafchamps and Pender (1997) who show that Indian households' desire to keep some liquidities reduces their willingness to invest in non-divisible risk-reducing irrigation technology. To show this formally, let X_t denote cash in hand, i.e., $X_t = W_t + y_t(W_t)$ where W_t is the agent's liquid wealth at the beginning of period t

and $y_t(W_t)$ is the agent's realized income, which includes return to liquid wealth. Agents have access to two i.i.d. income streams with probability distributions $F(y;\tau_0)$ and $F(y;\tau_1)$ with the second stochastically dominating the first; any risk averse agent prefers the second distribution. However, moving for the first income distribution to the second requires a sunk investment *k*. The Belman equation after the investment has been made is:

$$V_1(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - W_{t+1}) + \beta \int_0^\infty V_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1};\tau_1) \tag{56}$$

where $U(.)$ is the agent's instantaneous utility function and $V_1(.)$ is the agent's value function after having undertaken the irreversible investment *k*. Before making the investment, the agent's Belman equation is:

$$V_0(X_t) = Max\{V_0^1(X_t),\ V_0^0(X_t)\} \tag{57}$$

where $V_0^1(X_t)$ is the value of investing:

$$V_0^1(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - k - W_{t+1}) + \beta \int_0^\infty V_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1};\tau_1) \tag{58}$$

and $V_0^0(X_t)$ is the value of not investing:

$$V_0^0(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - W_{t+1}) + \beta \int_0^\infty V_0(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1};\tau_0) \tag{59}$$

The agent invests if $V_0^1 \geq V_0^0$.

Fafchamps and Pender (1997) show that agents with a precautionary motive for saving may want to hold liquid balances immediately after the investment is made. In other words, they may not want to spend all their liquid assets, which they keep in part to deal with emergencies, to cover the sunk cost of even a profitable investment. The rationale behind this result is easy to understand: an agent who has frozen all his assets into a single irreversible investment cannot self-insure against life's contingencies.

1.2 Property rights and asset markets

In the preceding chapter we argued that individuals may liquidate assets in order to deal with shocks. For this approach to be feasible, individuals must have well defined and adequately protected property rights on these assets. This need not be the case. In much of Sub-Saharan Africa, for instance, land tenure systems provide fairly secure usufruct rights to farmers but prohibit land sales (e.g., Atwood (1990), Platteau (1992)). As a result, farming households cannot liquidate land to deal with shocks. In India, although a land market exists, very few transations take place and creditors hesitate before foreclosing on farmers' land. Although the absence of fully individualized land rights have been accused of resulting in inefficient allocation of resources (e.g., Gavian and Fafchamps (1996), Feder (1987)), it may be understood as an effort to minimize the long-term divergence in incomes that Zimmerman (1993) have shown is associated with fully active land markets. In other words, laws and customs restricting land sales probably illustrate a society's effort to maintain social cohesion and preserve equality in the long run. They may also result from a desire to bar outsiders from acquiring land in the community. Restrictions on land sales need not imply less capacity to cope with risk if risk sharing institutions are provided that substitute for individual accumulation.

For similar reasons, societies may discourage labor bonding through the interdiction of slavery. Refusing to recognize and protect the property rights of slave owners significantly lowers their expected gain from labor bonding. Consider, for instance, the fate of an individual who discounts the future with discount factor delta and has voluntary entered into an indenture contract. The contract stipulates a constant but low level of consumption $\underline{c}$ forever.[45] The bonded laborer's expected discounted utility is thus $U(\underline{c})/(1-\delta)$.

Now suppose that if the bonded laborer were to renege on the contract, he or she would get an income π_t that evolves over time according to the following process:

$$\pi_{t+1} = \rho\, \pi_t + \varepsilon_{t+1} \tag{60}$$

where ε is an i.i.d. shock. When the property rights of slave owners are protected by law, there is a good chance that runaway slaves will eventually be returned to their owners, probably after a good beating. In this case, running away is unlikely to be an attractive option. If slavery is illegal, however, labor bonding must be entirely self-enforcing. This in general lowers the value of bonded laborers. To see why, assume for notational simplicity that a runaway bonded laborer consumes π_t everty period; his or her discounted expected future utility is thus:

$$W(\pi_t) \equiv E_t \left[\sum_{s=1}^{\infty} \delta^s\, U(\pi_{t+s})\right] \tag{61}$$

It is clear that, as long as $\rho > 0$, $W(\pi_t)$ is an increasing function of current income π_t: high income today is correlated with high income tomorrow, and thus with high expected discounted future income.

A laborer voluntarily abides by the indenture contract as long as $U(\pi_t) + W(\pi_t) \leq U(\underline{c})/(1-\delta)$, that is, as long as the expected utility the laborer can get on his or her own is lower than what is guaranteed by the contract. If, however, $U(\pi_t) + W(\pi_t) > U(\underline{c})/(1-\delta)$, it is in the interest of the laborer to renege on the contract. Let $\varepsilon^*(\pi_{t-1})$ be the level of ε_t such that:

$$U(\rho\pi_{t-1} + \varepsilon_t) + W(\rho\pi_{t-1} + \varepsilon_t) = U(\underline{c})/(1-\delta) \tag{62}$$

For any ε_t larger than $\varepsilon^*(\pi_{t-1})$, the bonded laborer reneges on the contract. The probability of breach of contract β_t is thus $\int_{\varepsilon^*(\pi_{t-1})} dF(\varepsilon)$. Since ε^* is a decreasing function of π_{t-1}, this probability is increasing in π_{t-1}. It is clear that the probability of losing runaway slaves reduces the value of the labor bonding contract to the slave owner relative to a situation in which their property rights over slaves are externally enforced. This probability is highest when the external options of candidate bonded laborers are attractive, that is, when π_{t-1} is high, and when the chance is high that a bonded laborer will experience a shock high enough to induce breach, that is, when the variance of ε_t is high. Voluntary labor bonding is thus more likely to arise when the labor market is characterized by significant monopsony power and self-employment is unattractive.

A similar reasoning indicates that debt peonage is less attractive for lenders if usurious interest rates are prohibited by law. Indeed, it implies that it takes longer for debt to build up and thus that lenders cannot as easily enlist the assistance of the courts to seize the assets of a

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[45] At the cost of additional but straightforward notation, the same argument can be extended to finite duration indenture contracts.

debtor who seeks to escape debt slavery. Usurious interest rates may still be practiced, but they must then be self-enforcing: debt peons will service their debt as long as the minimum stable consumption that is guaranteed to them by the patron/lender provides them with an expected discounted utility higher than $U(\pi_t) + W(\pi_t)$. Otherwise, it is optimal for them to breach the contract. An immediate corollary is that lenders will lend less if usurious interest rates are outlawed.

We shall revisit these issues when we discuss self-enforcing risk sharing contracts and quasi-credit. What we wish to emphasize here is that the liquidation of productive assets to deal with shocks is an option that requires the existence of alienable property rights on these assets. This is not saying that allowing usury or slavery would be better for society because they result in more efficient risk sharing. It goes without saying that a minimum level of equality is in the social welfare function of many societies -- as well as that of the international community -- and that allocations of resources which involve slavery, usury, and high levels of land concentration are undesirable. Many societies *de facto* discourage distress sales of land and future labor, undoubtedly to minimize their negative social consequences. The point of this discussion is rather that, if equity objectives are to be achieved in a sustainable manner, one must take into account the natural tendency for desperate enough people to propose their future labor and earnings as guarantee against distress borrowing. Similarly, to achieve an equitable distribution of land, it is not sufficient to redistribute it; one must also ensure that land concentation does not reemergers as a result of distress sales. Without proper safety net for the poor, laudable efforts to eliminate particularly scandalous symptoms of destitution are likely to fail.

1.3 The difficulties of precautionary saving

Households' efforts to insulate themselves against risk by accumulating assets on which they have well defined property rights are also subject to numerous constraints. The paucity of savings instruments makes it difficult and costly for them to accumulate precautionary balances. Consider, for instance, poor impatient households for whom precautionary saving is an essential risk coping strategy. As Deaton (1991) has shown, these households will save even if the return to liquid assets is negative. The reason is that their motive for saving is not to take advantage of financial opportunities but rather to set up a buffer stock that helps them smooth consumption and deal with emergencies. If the only available liquid asset has a negative return, poor households may choose to hold it anyway as a hedge against risk.

The willingness of the poor to hold assets with low or negative returns open the door to numerous abuse. When cash balances constitute an essential part of the poor's liquid assets, as suggested by Lim and Townsend (1994), inflation is a major tax on their meagre savings. This has potentially devastating effects on the poor's capacity to save and hedge against risk (e.g., McKinnon (1973)). Rural populations fortunate enough to be located close to a bank have been shown to make an intensive use of savings and deposit accounts (e.g., Behrman, Foster and Rosenzweig (1997)). Rates of return offered on financial savings instruments accessible to the poor are very low in most developing countries -- as well as in many developed countries. Fafchamps, Pender and Robinson (1995), for instance, indicates for Zimbabwe that rates of return in 1994 were around 18% for savings account and around 36% for money market accounts; during the same period, annual inflation reverted around 25%. The example shows that small investors were receiving a negative real return on their savings while large investors with access to the money market were receiving a positive real return.

In response to the paucity of savings instruments for the poor, alternative institutions have emerged that serve their savings needs. Some of these institutions, such as rotating and savings associations (ROSCA's) have attracted a lot of attention in the recent literature (e.g., Besley, Coate and Loury (1993), Besley and Levenson (1996), van den Brink and Chavas (1997)). In their simplest form, ROSCAs are financial contracts by which a group of people pledge to periodically contribute a fixed amount to a rotating fund which is allocated to each member in turn. As Besley and Levenson (1996) has shown, this arrangement enables participants to save faster, on average, than they could on their own. Furthermore, the obligation to contribute periodically to the fund imposes a discipline on small investors that they find hard to impose to themselves. It also helps them shelter funds from competing demands by friends and relatives. ROSCAs have the added advantage of reducing the incidence of the inflation tax that investors must bear: since cash balances are not held by the group but allocated to one member and spent immediately, the group does not hold cash balances for any length of time.[46] More complicated arrangements enable participants to bid for the collected fund, thereby introducing an interest rate element into the contract.

In spite of the attention they have received, ROSCAs are probably less important for the rural poor than is often assumed. The obligation to make fixed periodic payments is ill-suited to households whose income is highly seasonal and subject to the vagaries of the weather. ROSCA's seem most popular among market traders, for whom it is a way of protecting working capital from competing consumption demands, and among salaried workers, for whom it is a way of speeding up consumer durable expenditures. ROSCA's are also rare among urban enterprises, except perhaps among small trade firms (e.g., Fafchamps et al. (1994), Fafchamps, Pender and Robinson (1995)).

There are many other institutions catering to the savings needs of the poor. Many of them are discussed in Steel et al. (1997). Savings contract offered, for instance, by Ghanaian *susu* collectors ressemble ROSCA's in that fixed periodic payments are stipulated, to be returned in bulk to the client at the end of a set number of payments. The only difference is that the contract is passed with an individual who takes a commission, instead of a group. Savings cooperatives are another type of institution catering to the saving needs of the poor, albeit in a somewhat more formal manner. Participants to savings cooperatives can often borrow on their own funds and those of their friends, thereby enhancing the self-insurance role of such funds. Unfortunately, prudential regulations in many developing countries are either too lax or go unenforced. As a result, many savings cooperatives turn into pyramid schemes that defraud small investors (e.g., Steel et al. (1997)). In general there remains a dearth of safe and convenient savings instruments for the poor.

Whenever saving in formal or informal financial institutions is unfeasible, the rural poor must save in real assets. Saving in real instead of financial assets is subject to a substantial price risk that is compounded by the poor integration of agricultural markets. Fafchamps and Gavian (1996), for instance, shows that livestock markets in Niger are poorly integrated over space. The same is true for many grain markets (e.g., Dercon (1995), Baulch (1997), Ravallion (1986)). As a result, farmers are less able than often thought to use real assets to smooth large income shocks such as droughts. Fafchamps, Udry and Czukas (1996), for instance,

[46] Inflation incidence within the group, however, varies between those who receive the money early and those that receive it late. Even in the absence of inflation, ROSCAs reduce the amount of money held in the economy and thus the amount of seignorage paid by agents. Although ignored in the current literature, these issues are probably important, as evidenced by the fact that, as a rule, poor economies often are cash-poor.

show that Burkinabe households that were badly hit by the 1984 drought managed to absorb less than 20% of their income shortfall through livestock sales. This occured in spite of the fact that the large majority of surveyed households still held livestock after the drought. Results such as these cast serious doubt on the effectiveness of asset accumulation to deal with large weather shocks.

Section 2. Risk Sharing, Self-Interest, and Commitment Failure

We have seen that income diversification and precautionary saving are fraught with problems. Risk sharing is not devoid of difficulties either. The main reason is commitment failure. To see why, note that mutual insurance is Pareto improving whenever agents are risk averse and risk is at least partly idiosyncratic. Consequently, there exist mutual insurance contracts to which agents would voluntarily agree *ex ante*. In other words, if $U_i(.)$ is concave and $\pi_{i,t}(s_t)$ varies across individuals, then there exist a set of contingent promises $\tau_i(s_t)$ such that:

$$EU_i(\pi_{i,t}(s_t) - b_{i,t}(s_t) + \tau_i(s_t)) \geq EU_i(\pi_{i,t}(s_t) - b_{i,t}(s_t)) \quad \text{for } all\ i \tag{63}$$

with $\sum_i \tau_i(s_t) = 0$ for all t and s_t. Although agreeing to contract $\tau_i(s_t)$ is always individual optimal *ex ante, it is never in agents' short-term* self-interest to respect the contract whenever $\tau_i(s_t) < 0$, that is, when they are asked to assist others. Of course, if nobody ever helps others *ex post,* there is commitment failure: mutual insurance is not achieved and the outcome is socially suboptimal. The question then is: what mechanism can be used to ensure that commitment failure is avoided and Pareto gains are achieved? We review three types of systems that can potentially overcome commitment failure: social insurance; family values; and long-term relationships.

2.1 Social insurance

Mutual insurance agreements can in principle be enforced by an external agency such as a system of laws and courts. External enforcement is indeed the rule for the multitude of mutual insurance programs that constitute the welfare system of advanced countries. In fact, many of these countries have opted for compulsory insurance systems whereby agents' contributions are collected in the form of taxes instead of voluntary purchase of insurance contracts. A compulsory system offers the advantage of avoiding the adverse selection problem common to all insurance: agents who face a lower risk may find it cheaper to self-insure, thereby undermining the financial viability of the mutual insurance arrangement.

Poor rural communities often have compulsory arrangements as well. They mostly take the form of forced labor contributions to the provision of public goods and the constitution of welfare funds managed by the village chief or the community elders. As any form of taxation, forced labor contributions or *corvée labor* can be diverted by powerful individuals to serve their individual interests. Accusations of abuse, whether justified or not, tend to undermine the legitimacy of corvée labor and other social insurance institutions, and hence to raise popular resistance to taxation.

Although it is difficult to calculate how effective social insurance institutions are, impressions from the field suggest that traditional social insurance systems are moribund in many rural areas of the Third World (e.g., Platteau (1991)). Household surveys, for instance, hardly ever report any significant activity associated with explicit social insurance systems, such as corvée labor (e.g., Cleave (1974)). Other forms of labor assistance appear similarly obsolete. Using detailed labor data from Burkina Faso, Matlon and Fafchamps (1989), for instance, show that invitation labor and labor gangs, two institutions that partly serve the role of labor assistance, account only for minute amounts of labor provided by rural households. Rural sociologists and anthropologists similarly report that, in much of the Third World, social institutions meant to explictly share risk are essentially either inexistent or devoid of content (e.g., Scott (1976), Popkin (1979), Poewe (1989)).[47]

An alternative form of semi-formal social insurance is the reliance on charity to support the poor. Although charity can, in principle, be based on humanism and altruistic feelings towards fellow men, in practice it is often based on religious obligation. Religious taxes such as *zakat* are examples of such obligations. For social obligations originating in formal institutions and contracts, the legal use of force offers an ultimate recourse against recalcitrant individuals and thus serves as enforcement mechanism. Religious obligations are seldom enforced in this manner. Social pressure and individual guilt are used instead. Guilt is itself nurtured through religious and family education. Although these enforcement processes are hardly formal in nature, they are activated by formally organized groups and they serve to fund social programs that are controled by these same groups, at least partially.

Not all religions are equally active on the social insurance front.[48] Whatever the reason for the progression of different religions among Third World populations, the fact remains that churches have taken over many social responsibilities. The emphasis on social insurance is strongest among certain Muslim brotherhoods and among evangelical churches, a factor that appears behind their recent success in making new Sub-Saharan and Latin American converts.[49] Poewe (1989), for instance, views evangelical churches in rural Zambia as a way for households to recreate traditional institutions of social insurance that had fallen in disregard. She argues that the rise of evangelical churches further undermines traditional values as new converts opt out of traditional sharing mechanisms and turn to their new 'family' instead.[50] Geertz, Geertz and Rosen (1979) and Cohen (1969) give similar examples of the role of Muslim religious authorities in enforcing cooperation among traders.

Just like traditional institutions, religious organizations can be perverted to serve the interests of a few. Ellsworth (1989), for instance, tells the fascinating story of a Muslim holy man living in a Burkinabe village. Ellsworth traces all the gifts and transfers taking place

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[47] Although some social scientists argue that these social institutions have gone out of fashion due to the rise of capitalism and individualism (e.g., Scott (1976)), it is unclear whether they ever were truly effective (e.g., Popkin (1979), Fafchamps (1992)). Accounts of the past workings of social institutions are indeed subject to memory and age bias and to the idealization of the past.

[48] Animist beliefs, for instance, aim at putting people in communion with their immediate physical environment; consequently, they create a strong identification with a particular geographical setting. As a result, animists may not share a sense of community with humanity as a whole and feel no charitable inclination toward people outside their immediate kin group. In contrast, religions such as Budhism, Christianity, and Islam are open to all men and women and strive to build a sense of community that bypasses geographical distinctions. In fact, one may argue that large religions developed precisely as a response to the need for a cement to keep larger communities together. This need is strongest in urban areas where animist references become meaningless and lead to unhealthy cleavages among people. The penetration of outside religions such as Islam and Christianity into Sub-Saharan Africa through cities is in line with this observation. These observations are essentially speculative, however. Rigorous evidence on the relationship between religion and risk sharing is largely inexistent.

[49] The emphasis on social programs also seems to have been instrumental in the political clout gained by Islam fundamentalist movements such as the Palestinian Hamas, the Algerian Islamic Salvation Front, and the Lebanese Hezbollah.

[50] For a model of this process, see for instance the one developed by Hoff (1996) to deal with mutual insurance. We discuss Hoff's model more in detail below.

among villagers and notices that the holy man is at the center of a dense network of gifts. Many of these gifts are presented by villagers as charitable contributions to the holy man's social programs. Ellsworth then notes that, although the holy man himself has very few assets, redistribute all he gets, and ostentatiously lives in a very poor house, his brother with whom he spends most of his time is quite rich and is a main recipient of the holy man's largesse. Although the brothers retain only a small portion of the money collected and quite a bit of redistribution takes place through them, the story nevertheless serves as a cautionary tale against putting too much faith in organized social insurance in a Third World rural setting.

2.2 Family values

Another way for individuals to commit to sharing risk with others is by teaming up with them (e.g., Ben-Porath (1980)). Marriage is such a commitment mechanism. In all societies, marriage creates an extremely strong set of contractual obligations between two people, arguably stronger than any other contract. In Western Law, for instance, husband and wife owe each other help and assistance. The obligation to support a spouse in need extends beyond the dissolution of marriage, as evidenced by the practice of alimony payments. Many poor rural societies replace alimony by asset transfers but the rationale is the same: by marrying each other, two individuals incur mutual assistance obligations from which they cannot escape even upon dissolution of their union. In many cases, these obligations even carry over after death: the estate of the deceased is often obligated to assist the surviving spouse. Unless their nuptial agreement stipulates otherwise, husband and wife also often share upside risk through common property of assets and inheritance laws. Given the extraordinary nature of marriage obligations, it is no surprise that weddings are highly ritualized and widely celebrated affairs the world over.[51]

Parenthood is another source of mutual assistance obligation that is legally binding: in many societies, children are legally entitled to receive support from their legal parents. Although there are variations across human societies, e.g., relative hereditary rights of male and female children, it is a generally recognized *legal* principle that parents must take care of their progeny. Like marriage, parenthood obligations carry over after death or upon separation. For instance, in many legal systems it is unlawful for parents to fully desinherit their children. In Western Law, children are entitled to child support from parents who have not been granted custody or even visitation rights. Similar principles can be found elsewhere.

Granting legal protection to mutual obligations within the family does not, however, guarantee that these obligations are always respected. For instance, there are circumstances such as warfare and civil strife in which legal institutions cease to function. In these cases, legal protection cannot be granted to abandoned spouses and children. Even if legal institutions are functioning, legally forcing individuals to take care of their dependents is not an easy feat. For instance, people may move to escape their obligations. Many poor countries lack an efficient individual identification system such as an identity card, so that it is extremely difficult to trace someone who has skipped town. Even if the person can be found, forcing them to pay is itself problematic. Poor rural dwellers have few assets that could possibly be seized, and seizing them may be counterproductive: taking away a weaver's loom will not help the weaver meet his family obligations in the future. Unlike in developed economies, the rural poor are mostly self-employed, and if they work for a wage, it is as casual workers.

[51] The fact that marriage laws may be unwritten and enforced through traditional courts using traditional procedures does not subtract from their legal nature.

Consequently, child and spouse support payments cannot be collected directly from employers. Finally, even if the person can be traced and legal obligations enforced, the protection offered by the law is not instantaneous.

Given these limitations on the legal enforcement of contracts, it is hardly surprising that family obligations are not always met. Descriptions of famines are replete with accounts of split families and abandoned children. Greenough (1982), pp.215-225, for instance cites examples of nuclear households breaking up during famines. Similar evidence is reported by Alamgir (1980), pp.133-135 and 179. The 1984 Ethiopian famine, for instance, generated 100,000 ’orphans’, many of whom were in fact separated from their parents. Similar developments could be observed in the wake of the Rwandan refugee crisis. It would be unfair to treat all separation as voluntary. After all, as Sen (1981) demonstrated, emergency work migration by able bodied males is a common risk coping strategy. The extent to which families become separated during famines is, however, a cause for concern. It shows that, when households are subjected to inordinate stress, they often fail to perform their risk sharing function.

Households also fail and separate for reasons that have nothing to do with famines, warfare, and other collective crises: e.g., death, infertility, and incompatibility. When households split, the ability of their former members to deal with risk is often greatly diminished. Less able to deal with shocks, they also tend to be poorer. Studies of homeless populations, for instance, often indicate a strong correlation between dysfunctional families, risk, and destitution. Similar patterns can be found in poor rural areas. Household surveys, for example, often show that women living alone, because their husband is either dead or has left them, are systematically poorer than households in which both husband and wife are present. These examples confirm, *in absentia*, the important role of family in dealing with risk.

2.3 Informal risk sharing arrangements

There are ways to minimize commitment failure other than recourse to social institutions or the legal system. One is for individuals to enter into long term informal relationships with each other. To the extent that such relationships contain an implicit obligations to reciprocate -- e.g., ’I am willing to help you today because I expect you to help me later’ -- the desire to preserve the relationship becomes its own enforcement mechanism (e.g., Posner (1980), Platteau (1991)}. Such relationship-based informal risk sharing arrangements or IRSA’s are the focus of the rest of this section.

IRSAs were first formalized by Kimball (1988) and Coate and Ravallion (1993). Both use repeated games to demonstrate that an implicit agreement to share risk can be sustained through repeated interaction and thus that promises to assist others can be self-enforcing. Their argument can be generalized as follows. Consider an exchange economy in which output cannot be stored, assets cannot be accumulated, and there is no borrowing and lending from the rest of the world. People derive utility from what they consume $U_i(c_s^i)$, and at least some people are risk averse, i.e., $U''_i < 0$ for some i’s. Let $\delta \in (0,1)$ be a common discount factor and let Q denote a sequence of action profiles or *path* of the economy. Define $\omega_i(Q)$ as agent i’s discounted expected payoff along that path, i.e.:

$$\omega_i(Q) \equiv \sum_{t=0}^{\infty} \delta^t EU_i(\pi_{s,t}^i - \tau_{s,t}^i(Q))$$

where the $\tau_{s,t}^i(Q)$ refer to actual transfers at the end of each period t dictated by action profiles Q.

Following Abreu (1988), $N + 1$ strategy profiles are sufficient to span the complete set of equilibrium payoffs of this economy: one cooperative risk sharing strategy profile denoted Q^0, and one punishment strategy profile Q^k for each of the $k \in \{1,...,N\}$ agents. Agents play according to Q^0 as long as nobody deviates, and switch to Q^i following a defection by agent i either to the initial path Q^0 or to any of the punishment paths Q^k. Abreu (1988) showed that, provided punishments Q^k are the harshest that can be credibly inflicted on deviant agents, adding other more complex strategies cannot expand the set of equilibrium payoffs -- and thus the extent of risk sharing. Voluntary participation to informal risk sharing implies that agents cannot be maintained below the expected payoff they could guarantee themselves by exiting the risk sharing group. Since autarky is the Nash equilibrium of the one-shot game, autarky payoffs serve as maximum punishments:[52]

$$\omega_k(Q^k) = \frac{EU_k(\pi_s^k)}{1-\delta} \quad \text{for} \quad k \in \{1,...,N\}$$

Along the equilibrium path Q^0, net transfers between agents depend not only on their own realized income but also on that of all other agents. This imposes high informational requirements as agents must monitor each other's income to spot defections (e.g., Fafchamps (1992), Ligon (1996). One therefore expects IRSAs to be more prevalent among tightly knit communities where information circulates freely, e.g., fishing communities where the catch of the day is commonly observed, and farming communities where yields can be visually estimated by all (e.g., Platteau and Baland (1989), Platteau (1991)).

As is well known, the set of subgame perfect equilibria of a repeated game is very large (e.g., Fudenberg and Maskin (1986)). IRSAs are no exception. Kimball (1988) and Coate and Ravallion (1993) get rid of the multiplicity of equilibria by positing that a social planner picks the allocation that maximizes the unweighted sum of individual utilities subject to participation constraints. In practice, the choice of an equilibrium is likely to depend on bargaining within the risk sharing group. Bargaining power probably depends on the threat point of each member but also on their negotiating skills, ethical considerations, past experience, altruism, and ideology, as well as on the group's polity. The interplay of these factors makes the outcome hard to predict. There is no reason to believe all bargaining processes converge to the allocation picked by Kimball and Coate and Ravallion's social planner. Much can nevertheless be said about IRSAs by looking at the *set* of equilibria itself and studying how its boundary evolve as conditions change. This is the approach adopted here.

The set of equilibrium payoffs are comprised between the Pareto efficient frontier and a set of voluntary participation (VP) constraints which must be satisfied along any equilibrium path *after* the realization of s:

$$U_i(\pi^i_{s',t}) - U_i(\pi^i_{s',t} - \tau^i_{s',t}(Q^k)) \leq \delta\omega_i(Q^k) - \delta\omega_i(Q^i) + A_i \tag{64}$$

for all $s' \in S$ and all $k = 0, 1, \cdots, N$. Participation constraints require that, for any realization of the state of nature s', the short-run gain from deviation $U_i(\pi^i_{s',t}) - U_i(\pi^i_{s',t} - \tau^i_{s',t}(Q^k))$ must be smaller than the discounted long-run gain from cooperation $\delta(\omega_i(Q^k) - \omega_i(Q^i))$. It is clear from equation (2) that VP constraints are never binding when $\tau^i_{s',t}(Q^k) \leq 0$. Voluntary

[52] This does not mean that permanent exclusion is the only possible form of punishment. The expected discounted payoff of a punished agent cannot fall below his or her expected discounted autarky payoff, otherwise the agent would defect from the punishment path. But punishments can be front-loaded (e.g., Abreu (1986): the payoff of the punished agent can temporarily be brought below the autarky payoff provided that the punishment phase is limited in time.

participation is problematic only when Q^k requires an agent to help others.

Many social scientists have argued that reciprocity is often reinforced by an ideology or culture that emphasizes the right to subsistence and the corresponding moral obligation to assist someone in need (e.g., Scott (1976), Keyes (1983), Brocheux (1983), Feeny (1983)). To reflect this view, we have added the term $A_i \geq 0$ to capture the subjective satisfaction agents may derive from 'doing the right thing'. Alternatively, A_i can represent the guilt people may feel for reneging on their promises. Social sanctions other than exclusion from risk sharing -- e.g., exclusion from other forms of social interaction, shunning -- are included in A_i.

The emphasis that most traditional Third World cultures puts on solidarity has led some to believe that participants to mutual insurance arrangements are solely motivated by altruistic feelings and ethical principles. This view has been severely criticized by Popkin (1979) and others as much too naive. There is plenty of evidence that self-interest motivates behavior in traditional as well as modern societies (for particularly colorful examples, see, for instance, Poewe's (1989) account of kinship in Zambia). Ethics and well understood self-interest need not be conflictual, however (Posner (1980)). As equation (64) illustrates, they are largely complementary: VP constraints are indeed easier to satisfy and more efficiency in risk sharing can be achieved when A_i is large, that is, when agents are altruistic or feel guilty for letting others down. This can easily be shown formally. Let $\Omega(A)$ be the set of subgame perfect equilibrium payoffs corresponding to a particular value of A for all $i \in N$. Then we have:

Proposition III.1: Suppose $A^1 \leq A^2$. Then $\Omega(A^1) \subseteq \Omega(A^2)$.

Since affection is the primary source of altruism, proposition 1 implies that risk sharing is expected to be strongest among members of the same family or lineage and among friends and neighbors (e.g., Ben-Porath (1980), Foster and Rosenzweig (1995)). Religious fervor also creates strong bonds between groups of converts and can serve as the basis for much mutual insurance and charity. Furthermore, the altruistic desire to help others and the ability to feel guilty for failing to do so can be cultivated through education and enhanced through personal interaction (e.g., Platteau (1994), Platteau (1994)). For all these reasons, it is not surprising that Third World communities often describe IRSAs in emotional or moralistic terms. Altruism alone, however, may be insufficient to support much risk sharing. In the remainder of this section we seek to understand when altruism and ethics are most put to the test by studying the extend to which self-interest can, on its own, support risk sharing.

2.4 Gifts and risk sharing

We begin our analysis of commitment failure in long term relationships by focusing on gifts. Formally, this means that we temporarily restrict our attention to 'stationary' strategies, that is, to strategies that depend only upon the current state of nature s, not on past transfers. Strategies are affected by the past history of play only inasmuch as defection and punishments are concerned. In this case, VP constraints take a simpler form:

$$U_i(\pi^i_{s'}) - U_i(\pi^i_{s'} - \tau^i_{s'}) \leq \frac{\delta}{1-\delta} E[U_i(\pi^i_s - \tau^i_s) - U_i(\pi^i_s)] + A_i \tag{65}$$

VP constraints (65) impose serious restrictions on IRSAs that can account for a number of stylized facts about gifts and risk sharing that cannot easily be accounted for in models exclusively based on altruism (e.g., Becker (1981), Ravallion and Dearden (1988)). First of all, self-interested risk sharing cannot be supported when agents are impatient or when they do not expect to interact for long, that is, when δ is low. This is a well known property of repeated games (e.g., Fudenberg and Maskin (1986)). An implication is that risk sharing based on long-term relationships is more difficult to sustain among highly mobile populations, such as urban migrants (see, for instance, Hart (1988) for evidence in Ghana). The shape of the equilibrium payoff set for various values of δ is shown in Figure III.1.[53] The figure illustrates the well known result that the set of equilibria of a repeated game shrinks as agents get more impatient.

By pooling the resources of agents with different income streams, risk sharing can in principle redistribute incomes from agents with high average incomes to those with a low average income. Such redistribution is achieved by granting to the poor a larger share of the welfare gains from risk sharing. In this case, solidarity not only reduces temporary poverty; it also palliates chronic poverty. Self-interest, however, puts limits on redistribution that are particularly stringent if agents are impatient:

Proposition III.2: As δ decreases, gains from risk sharing must be shared more equally.

Proposition III.2, which is illustrated in Figure III.1, implies that a redistribution of welfare is harder to achieve in communities with a short time horizon because all participants, rich and poor, then insist on receiving an equal share of the welfare gain from mutual insurance.

It has been observed that IRSAs occasionally ’break down’ during famines in the sense that people most in need fail to receive assistance. Sen (1981), for instance, notes that during the Ethiopian famine of 1974 many domestic servants were laid off by their employer even though it was clear that they would starve. The absence of risk sharing in bad times is difficult to reconcile with altruism but it can be explained by self-interest considerations. As Coate and Ravallion (1993) have shown, the discount factor required to induce an agent to share risk goes up as the income of others goes down: the lower the income of others, the harder it is to ensure voluntary income pooling. If the limited contribution that a relatively fortunate agent is willing to make is insufficient to keep others from severe hardship, then the IRSA will appear to break down.

Efficiency gains from risk sharing increase with risk and with aversion toward risk (e.g., Arrow (1971)). One would therefore expect risk sharing to be more prominent when incomes are more variable and agents are more risk averse. Kimball (1988) and Coate and Ravallion (1993) indeed present simulation results in which risk sharing increases with risk and aversion toward risk. It is, however, possible to come up with examples in which the reverse is true, as illustrated in the following proposition:

Proposition III.3: Take any stationary IRSA in which some efficiency gains from risk sharing are realized (A1). Suppose that there exist at least one binding participation constraint for one agent, say agent i. Then:

(1) Provided certain technical assumptions are satisfied (see proof), there exists a concave transformation of the utility function of agent i such that the participation constraint is violated.

(2) Let N be the number of participants to the IRSA and let S be the number of possible states of the world. Then, if $S \geq 2N + 2$, there exists a mean preserving spread in risk such that agent i’s participation constraint is violated.

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[53] Figure III.1 was constructed by computer simulation, using stationary strategies and assuming that $A = 0$, $N = 2$ and $U_i(y) = log\,(y)$

The proof of proposition 3, given in Appendix, is built on the realization that two opposite forces are at work in any IRSA: an increase in risk or risk aversion raises the gains from risk sharing, thereby raising the right hand side of the VP constraints (3). But it may also increase the subjective cost of sharing risk $U_i(\pi^i_{s',t}) - U_i(\pi^i_{s',t} - \tau^i_{s',t}(Q^0))$, particularly if helping others entails one's immediate starvation.[54] Depending on the net effect of these two forces, the set of sustainable equilibria may shrink or expand. Proposition III.3 thus helps explain why risk sharing often appears limited or inexistent among the extremely poor and the destitute. It also suggests that a reduction in average group income and an increase in income variability, e.g., because of increased population pressure or of environmental degradation, may undermine an existing IRSA.

2.5 Exclusion and renegotiation

So far we have assumed that the IRSA is supported by the threat of exclusion: an agent who refuses to cooperate is excluded from the sharing risk group. This threat is not entirely credible, however, because, refusing to share risk with a deviant agent penalizes the group as well. This is most easily seen in a two-person relationship: if *A* breaches *B*'s trust, *B* should punish *A* by refusing to share risk with *A*, but doing so hurts *B* as well. Consequently, *A* could convince *B* to show forgiveness. This prospect weakens the penalty for cheaters and undermines cooperation (see Farrell and Maskin (1989), Pearce (1987), Abreu, Pearce and Stacchetti (1993) for a discussion).

IRSAs can survive *ex post* renegotiation provided that some limits are placed on the gains that excluded agents can achieve through renegotiation. This is, for instance, the case if we require that strategies be weakly renegotiation-proof in the sense of Farrell and Maskin (1989). According to this definition, a strategy is weakly renegotiation-proof if, among its possible continuation equilibria, none strictly Pareto dominates another. This requirement ensures that non-deviant agents are not penalized along punishment paths.[55]

A simple example of weakly renegotiation-proof equilibrium is one in which deviant agents continue to share risk with the group but have to pay a (possibly contingent) fine for *T* periods. To illustrate how such an equilibrium can be constructed, let p^I_s stand for a vector of contingent punishment transfers that follow a defection by agent *i*. Along *i*'s punishment path, the transfer rule p^I_s is followed for T_I periods, after which agents revert to the cooperative stationary rule τ_s. Then we have:

Proposition III.4: The strategy profile $(\tau_s\,, p^1_s\,, \;\cdots\;, p^N_s)$ is subgame perfect and weakly renegotiation-proof if there exist T_I such that, for all $i \in N$ and all $s \in S$:

$$U_i(\pi^i_{s'}) - U_i(\pi^i_{s'} + \tau^i_s) \le \sum_{t=1}^{T_I} \delta^t E[U_i(\pi^i_s + \tau^i_s) - U_i(\pi^i_s + p^{Ii}_s)] \tag{66}$$

$$U_i(\pi^i_{s'}) - U_i(\pi^i_{s'} + p^{Ii}_s) \le \delta^{T_I} E[U_i(\pi^i_s + \tau^i_s) - U_i(\pi^i_s + p^{Ii}_s)] \tag{67}$$

$$U_i(\pi^i_{s'}) - U_i(\pi^i_{s'} + p^{Ji}_s) \le \sum_{t=1}^{T_J} \delta^t E[U_i(\pi^i_s + \tau^i_s) - U_i(\pi^i_s + p^{Ii}_s)] \tag{68}$$

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54 Unless starvation is already certain, in which case sharing does not make any difference.

55 Continuation payoffs need no be (constrained) Pareto efficient, however: they may be dominated by continuation payoffs of paths other than Q^0. Deviant agents are thus assumed unable to challenge the status quo and propose a new equilibrium path. In the case of IRSAs, this seems a reasonable restriction given that the equilibrium strategy often is a social norm: renegotiation out of it is likely to prove difficult (e.g., Abreu, Pearce and Stacchetti (1993), DeMarzo (1988)).

$$E\left[U_i(\pi_s^i + p_s^{Ji}) - U_i(\pi_s^i + \tau_s^i)\right] \geq 0 \tag{69}$$

The set of weakly renegotiation-proof equilibria is illustrated in Figure III.2.[56] Renegotiation-proofness shrinks the set of equilibrium payoffs but does not eliminate the possibility of risk sharing if agents are sufficiently patient. Asking that an IRSA be renegotiation proof thus adds an element of realism: punishments never rely on complete exclusion and they must remain limited in time. Punished agents are requested to pay a fine that itself is contingent upon the state of nature. In practice, fines may take the form of additional requests for gifts and loans from the group. Other members of the group may also invite themselves to the table of the deviant agent, a simple but effective way of penalizing misbehavior.

Section 3. Sharing and Power

IRSAs are often perceived as being fundamentally egalitarian. The idea that pre-capitalist societies are fair and equal goes back to Rousseau's 'good savage' parable. Radical thinkers have sometimes pushed this idea so far as to suggest that, thanks to IRSAs, Third World rural communities behave like village communes. The romanticized portrayal of IRSAs, especially when it is used to justify radical political options, is what motivated Popkin (1979) to expose opportunistic behavior among Third World rural communities. The model presented here throws light on this debate.

On the side of the idealists, IRSAs have redistributive power. First, risk sharing is by definition redistributive: it takes away from those who currently have and gives to those who currently have not. Second, gifts are a non-market allocation mechanism. This has led some to believe that IRSAs are not bound by the initial distribution of endowments -- i.e., income streams. Third, IRSAs cultivate a solidarity ethic that can be interpreted as a favorable disposition toward redistribution. Provided that ethics and ideology are strong enough, IRSAs can potentially support Pareto efficient allocations that are more egalitarian than the initial distribution of income streams.

On the side of the sceptics, participation to IRSAs is voluntary. Even after accounting for ethics and ideology, individuals are unlikely to willingly part with a large proportion of their hard earned income without receiving something in exchange. This places considerable restrictions on the amount of redistribution that can be achieved through IRSAs. These restrictions are the focus of the following pages. We first demonstrate that risk sharing among poor and rich agents naturally takes the form of a patron-client relationship. We then illustrate how certain individuals may derive bargaining power from unusual risk characteristics, and hence capture welfare gains from risk sharing.

3.1 Patron-client relationships

It has long been documented that the sharing of risk between unequal agents takes a peculier form that has often been described as a patron-client relationship: a wealthy agent provides protection to a poor agent in exchange for repeated gifts and labor services.[57] The question we ask here is whether such protection is redistributive or exploitative, that is, whether it raises or lowers the average consumption of the poor.

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[56] Figure III.2 was constructed using a numerical simulation based on the equations for Proposition III.4 for a two-person IRSA.

[57] See, for instance, Scott (1976), Platteau (1988, 1995a, 1995b), and Greenough (1982), pp.207-215. Ellsworth (1989) presents numerical evidence that members of the village establishment receive net transfers from poorer members of the community.

Let us define an IRSA $\{\tau_s^i\}$ as actuarially fair for agent i iff $\sum_{s \in S} \tau_s^i = 0$ for that agent. An actuarially fair IRSA has no effect on average consumption and thus is neither redistributive nor exploitative. Decompose income π_s^i into average income x_i and an income shock e_s^i with $E[e_s^i] = 0$ for all i. Then we can show that risk sharing between rich and poor is likely to be exploitative:

Proposition III.5: Assume that absolute risk aversion is decreasing (A4) and tends to 0 as $x \to \overline{x} \leq \infty$ (A5). Then, unless $\tau_s^i = 0$ for all s, there exists a x^* such that, for all $x^i \geq x^*$, an actuarialy fair τ_s^i violates at least one of agent i's participation constraint.

The intuition behind proposition 5 is that, because of decreasing absolute risk aversion, the willingness to pay for insurance -- and thus the value of any IRSA -- decreases with average income x. As a result, agents that are rich enough cannot be convinced to voluntarily participate to an IRSA unless they are compensated in a way other than insurance itself. Instead of being redistributive, the IRSA must become 'exploitative': on average, it takes away from the poor and gives to the rich. Inequality in incomes is not eliminated by informal risk sharing, it is reinforced.

In practice, the poor are typically unable to make large payments to the rich. They can nevertheless buy protection in exchange for small but frequent services such as small gifts, prompt labor services (at the landlord's 'beck and call'), transfer of useful information, and provision of political support (e.g., Platteau (1988, 1995a, 1995b)). Asymmetry in incomes thus translates into a patron-client relationship. Studies of peasant revolts indicates that 'exploitation' remains reluctantly accepted as long as landlords and rural elites continue to provide insurance and protection. Revolts arise when the rural rich move to cities and maintain the machinery of exploitation but withdraw their patronage (Scott (1976), Watts (1983)).

Ironically for the idealist view of IRSAs, participation constraints generate more inequality than would result from market transactions, not less. To see why, suppose that a market for insurance did exist, that is, that risk sharing contracts were perfectly enforceable and did not have to be self-enforcing. Rich agents would accept any insurance contract that would guarantee them at least as much utility as they could get on their own. Agents rich enough to be (approximatively) risk neutral with respect to small risks would accept any mutual insurance contract that yields a non-negative profit, i.e., such that:

$$E\tau_s^i \leq 0 \tag{70}$$

By contrast, the VP constraint for a risk neutral agent requires that:

$$E\tau_s^i \leq -\frac{1-\delta}{\delta}\tau_s^i \tag{71}$$

Comparing equations (71) and (72), the rich require less compensation to share risk with the poor in the presence of perfect insurance markets than if risk sharing is achieved informally.[58] The reason is that IRSAs must be self-enforcing: the rich must accept to part with their money *after* the state of nature is known. To do so, they must see their future participation in the IRSA at least as beneficial as the money they have to give away today. In contrast, market exchange only requires that parties find it in their advantage to transact *ex ante*, before the state of nature is known. Since, by definition, market transactions prevent *ex post* defection, extra incentive need not be provided to ensure compliance.

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58 Given our sign convention, agents receive a compensation when τ_s^i is negative.

Equation (72) indicates that the expected size of future transfers is what determines the rich's immediate willingness to help the poor. If what the poor can pay on average is negligible, little insurance is provided. Individuals with a limited ability to generate income -- e.g., the disabled, the old, the permanently sick, orphans, widows -- may thus find it difficult to get insurance through an IRSA. They may have to rely solely on altruism and ethics and live off charity. In this respect, IRSAs are fundamentally different from market economies. In both cases private incentives fail to promote social protection for vulnerable segments of society. But agents in a market economy can protect themselves agains disease, disability, old age, or loss of a spouse by purchasing individual insurance beforehand. This option is not open to IRSA participants. They must rely either on others' altruism, or on their capacity to reciprocate in the future. VP constraints thus illustrate the difficulty IRSA participants may face in buying implicit insurance against, say, permanent disability through pure gift giving.

An immediate corollary of the above discussion is that if, for ideological or ethical reasons, society rejects patronage, then the rich will choose to opt out of the system and refuse to insure others. Hoff (1996) examines this situation in detail and shows that, when risk sharing is required to be actuarially fair, the size of the risk sharing group shrinks as income inequality increases. Platteau (1996) takes this approach one step further and argues that, in many cases, the rich cannot escape the risk sharing group and its redistributive logic. Individuals who dare to invest, take risk, and innovate do not, therefore, collect the full return to their investment. As a result, Platteau argues, the risk sharing ethics stiffles investment and entrepreneurship. We shall revisit these issues in the next chapter.

3.2 Power and coalitions

So far we have only considered individual participation constraints. We now explore what happens if agents can form coalitions and threaten to split from the group and create their own IRSA (e.g., Bernheim, Peleg and Whinston (1987), Bernheim and Peleg (1987)). Let us assume, for the sake of argument, that IRSA participants are free to form any coalition they want. Coalitions of agents can credibly oppose equilibria that grant their members a payoff vector strictly inferior to what they could get by forming a separate IRSA. To prevent the formation of blocking coalitions, IRSA participants must therefore be guaranteed a payoff vector that is at least as good as what they could get by splitting from the group and forming their separate IRSA. An equilibrium path that has this property is called coalition-proof.[59]

Coalition-proof equilibria are illustrated in Figures III.3 and III.4 in a three-person IRSA. Consider Figure III.3 first. The set of equilibrium payoffs for each of the two-person IRSAs are presented in each quadrant. Their Pareto frontiers are given by segments *AB*, *CD* and *EF* respectively for agents 1 and 2, 1 and 3, and 2 and 3. Form the closed convex set *OPABQO* by projecting the extremum points of the Pareto efficient frontiers to the axes in the first quadrant. Repeat the same operation in the other quadrants to get the closed convex sets *ORCDSO* and *OTEFUO*. A three-person payoff vector is coalition-proof if it lies outside and weakly above the three convex sets *OPABQO*, *ORCDSO*, and *OTEFUO*. Points strictly inside any of these sets are not coalition-proof: a coalition of two players could achieve a better allocation on its own and can thus credibly oppose it. *X*, for instance, is coalition-proof, but *Z* is not. The same process can be applied recursively to construct the set of coalition-proof

[59] Requiring that equilibria of repeated games be robust with respect to any coalition of agents is akin to requesting that it belong to the core or the stable set of feasible cooperative outcomes. By construction, perfect equilibria are robust with respect to 'coalitions' of a single agent since they satisfy VP constraints.

equilibria to a *N*-person IRSA.

Figure III.4 illustrates one of the implications of coalition-proofness for risk sharing. Again, there are three agents *A*, *B*, and *C*. The income of agent *C* is negatively correlated with that of *A* and *B* but the latter two have an identical distribution of income, i.e., $\pi_s^A = \pi_s^B$ for all $s \in S$. The scope for risk sharing between *A* and *B* is thus nil. If coalitions of two agents are not allowed, equilibria need only satisfy the participation constraints of each of the three agents. A point such as *M*, for instance, satisfies these requirements. Now let agents form coalitions and oppose allocations that fail to guarantee them what they could achieve by forming a separate IRSA. Any point *inside* the constrained Pareto frontier can be opposed by a coalition of agents. In this special case, most points *along* the Pareto frontiers can also be opposed by a coalition of *C* and one of the two agents. Take point *R*, for instance. At *R*, risk is shared efficiently between *C* and *B* but *A* is at his autarky payoff. *A*, however, can improve his lot by 'bribing' *C* to form an $A-C$ coalition that guarantees *C* a payoff higher than *R* and *A* a payoff higher than autarky. *B* can, in turn, retaliate by bribing *C* even more, etc. Repeating this process until convergence, we see that the set of coalition-proof equilibria of this game is the dashed line running from *X* to *Y* and from *Z* to *Y*. Along this line the expected utility of *C* is constant. It is the maximum that *A* or *B* in isolation could credibly promise *C* in order to lure her into forming an $A-C$ or $B-C$ coalition. The set of coalition-proof equilibria is non-empty even though it occurs where participation constraints are binding.[60]

When coalitions are allowed, the mere presence of an agent may confer rents to others. To see why, consider a small alteration to the preceding example and suppose that $\pi_s^B = \pi_s^A + \varepsilon$ for all $s \in S$. As long as *C*'s payoff is greater than the maximum payoff *A* could credibly promise her, she prefers to remain with *B*. Since *B*'s income is marginally higher than that of *A*, *B* can top any offer *A* can credibly make. Coalition-proof equilibria are thus those at which *B* and *C* form a risk sharing coalition and *A* is left in autarky. *A* does not derive any gain from the game, yet *A*'s willingness to form a coalition with *C* significantly increases *C*'s bargaining power and allows her to extract from *B* most of the Pareto efficiency gains from risk sharing.

These examples illustrate that allowing coalitions may confer considerable bargaining power to some agents, particularly those whose income stream is different from the rest of the group. In his study of Nigerian villages, for instance, Udry (1990) indicates that traders are able to establish patron-client relationships with local farmers because they have an income that is less sensitive to local climatic conditions (see also Watts (1983)). The same thing can often be said of government employees, pension recipients, and households receiving large migrant remittances in farming communities (e.g., Ellsworth (1989)).

Allowing the free formation of coalitions may also result in poor agents not receiving any insurance. The reason is that forming coalitions opens new avenues for the expression of self-interest. As a result, privileged members of the group can more easily oppose the egalitarian redistribution of consumption through risk sharing. Allowing coalitions, however, may promote efficiency. When coalitions are not allowed, only individuals can challenge a particular equilibrium path. Perfect equilibria can be very inefficient. By threatening to form a separate, better risk sharing group, coalitions can police IRSAs and eliminate sub-optimal outcomes. Because they bring the equilibrium path closer to the core, they also bring it closer to the allocation that would result from a perfect competitive equilibrium. The larger the risk sharing group and the more coalitions they may form, the closer coalition-proof equilibria

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[60] It is easy to verify that the core of the corresponding market economy is a single point at which *C* gets all the gains from trade.

must lie to the perfect competitive outcome and the less they can correct inequality in endowments. Achieving redistribution may therefore require that certain coalitions be combatted, possibly at the risk of reducing efficiency. More generally, the degree of equity or inequity achievable via an IRSA can be manipulated through the polity by allowing certain coalitions and preventing others.

Section 4. Risk Sharing, Credit, and Information

In practice, gifts and transfers seldom are the dominant form of consumption smoothing in the Third World; consumption credit is typically a more important avenue for sharing risk within the community (e.g., Rosenzweig (1988), Townsend (1994), Alamgir (1980), p.156-157). The resemblance between such consumption credit and market transactions is, however, largely superficial. The amounts transacted often are too small to justify court action; contracts must be self-enforcing.[61] Moreover, as recent evidence has shown, consumption credit is often implicitly combined with some form of insurance: debts can be forgiven, repayments can be postponed, and actual contractual performance typically depends on the lender's and the borrower's situation at the time of repayment (e.g., Udry (1990), Platteau and Abraham (1987)). We now show that quasi-credit can be understood as a non-stationary strategy equilibrium of a long term, implicit risk sharing arrangement (see also Kocherlakota (1996), Ligon, Thomas and Worrall (1997)).

4.1 Quasi-credit

So far we have focused on stationary strategies, that is, on strategies in which transfers depend only on the current state of nature. These strategies alone can support cooperation but less restricted strategies can achieve more. We investigate a special class of non-stationary strategies, one in which agents are individually rewarded for contributing to the group. As it turns out, this class of strategies establishes a formal link between risk sharing and credit practices.

Formally, consider strategies in which the consumption of agent i is the sum of three terms: realized income π_s^i, net transfers τ_s^i, and a reward w_t^i that, for the time being, we shall call brownie points:

$$c_{s,t}^i = \pi_{s,t}^i - \tau_{s,t}^i + w_t^i \tag{73}$$

Brownie points w_t^i can be thought of as the net wealth or goodwill capital of individual i.[62] They are not function of the current state of nature.

Let $\pi_{s,t}$ and w_t be the vectors of individual incomes and brownie points, respectively. Transfers $\tau_{s,t}^i$ map from the cross-product of realized incomes and brownie points at time t into the real line, i.e.:

$$\tau_{s,t}^i = \Pi^i(\pi_{s,t}, w_t) \tag{74}$$

Transfers depend on past history through w_t. Brownie points reward positive transfers to others, but since transfers are themselves function of realized incomes and brownie points, we can write the law of motion of w_t^i in the following reduced form:

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[61] In that, consumption credit formally resembles the way sovereign debt contracts have been modelled in the literature (e.g., Eaton and Gersovitz (1981), Kletzer (1984), Grossman and Van Huyck (1988)).

[62] w_t^i need not be expressed in monetary terms. In the *hau* system of exchange discussed by Sahlins (1972), for instance, goodwill takes a purely symbolical form.

$$w_t^i = W^i(\pi_{s,t-1},\, w_{t-1}) \tag{75}$$

Brownie points are normalized so that $\sum_{i \in N} w_t^i = 0$ for all t.

With these new assumptions, participation constraints can be rewritten:

$$U_i(\pi_{s'}^i) - U_i(c_{s'}^i) \leq \sum_{u=1}^{\infty} \delta^t EU_i(c_{s,t}^i) - \frac{\delta}{1-\delta} EU_i(\pi_s^i) + A_i \tag{76}$$

In this new notation, stationary strategies correspond to restricted transfer functions in which $\Pi(y,\, w_0) = \Pi(y,\, w_1)$ for all y, w_0, and w_1. Since non-stationary strategies are less restrictive than as pure gift giving, they should allow more risk sharing. This intuition is confirmed by the following proposition:

Proposition III.6: Let A be the set of perfect equilibria supported by the stationary strategies and let B be the set of perfect equilibria supported by non-stationary strategies defined above. Then $A \subseteq B$.

To illustrate that B can be strictly larger than A, consider the following simple example. Suppose there are two agents with the following concave utility function:

Consumption	1	1.5	2	2.5	3	3.5
Utility	-2	1	2	2.5	2.75	3

There are three equally likely states of the world, numbered 1 to 3. Corresponding income vectors of agents 1 and 2 are (1, 2), (2, 1), and (3, 3). Altruism is ignored, i.e., $A_1 = A_2 = 0$. We compare two risk sharing schemes. The first one, which is stationary, stipulates transfers from agent 1 to agent 2 of -0.5, 0.5, and 0 in states of the world 1, 2 and 3, respectively. The second scheme is like the first in states of the world 1 and 2. But in state 3, it stipulates that an agent receives a payment of 0.5 if the previous state of the world was 1 or 2 and he or she gave a transfer to the other agent. This payment can be thought of as contingent credit repayment. We show that the second scheme can be supported for a lower discount factor than the first.

Consider the first scheme. Given the symmetry of the game, there is only one participation constraint to consider, that when one of the agents must give 0.5 to the other. Expected utilities from cooperation and autarky are, respectively:

$$EU_i(c_{s,t}^i) = \frac{1}{3}U(3) + \frac{2}{3}U(1.5)$$

$$EU_i(\pi_s^i) = \frac{1}{3}U(3) + \frac{1}{3}U(2) + \frac{1}{3}U(1)$$

The difference between the two is 2/3. The gain from defection is $U(2) - U(1.5) = 1$. The VP constraint is satisfied for $\delta \geq 0.6$.

Now consider the second scheme. There are two participation constraints to satisfy. The first one, as in the stationary scheme, ensures that payment is made in states of the world 1 and 2. The expected utility from autarky and the gain from defection are unchanged, but the expected utility from cooperation has increased because of the reward in state 3. It is now:

$$\delta[\frac{1}{3}U(3.5) + \frac{2}{3}U(1.5)] + \frac{\delta^2}{1-\delta}\frac{2}{3}U(1.5) + \frac{1}{6}U(3.5) + \frac{1}{6}U(2.5)$$

The minimum δ at which the participation constraint is satisfied is now 0.588. The second participation constraint makes sure that payment of 0.5 in state 3 is self-enforcing. The minimum δ at which voluntary payment is made is 0.364. The second scheme can thus supports risk sharing in bad times even when $\delta < 0.6$. More general examples can be found in Ligon, Thomas and Worrall (1996).

As the above example suggests, quasi-credit belongs to the class of non-stationary strategies that we just discussed. To see why, let us split $\tau^i_{s,t}$ into two parts: a loan l and a pure transfer τ. Let the interest rate be r. Then:

Proposition III.7: For any interest rate r, and any function $W^i(y, w)$ and $\Pi^i(y, w)$, there exist a loan function $l^i(y, w)$ and pure transfer function $\tau^i(y, w)$ such that:

$$c^i_{s,t} = \pi^i_{s,t} - l^i(\pi_{s,t}, w_t) + w^i_t - \tau^i(\pi_{s,t}, w_t) \tag{77}$$

$$w^i_t = -(1+r)l^i(\pi_{s,t-1}, w_{t-1}) \tag{78}$$

Proposition III.7 establishes the formal resemblance between quasi-credit and a non-stationary strategy equilibrium of a repeated risk sharing game. Quasi-credit can thus be considered as a form of insurance. Proposition III.6 also teaches us that, in the absence of enforcement problems, efficient risk sharing could be achieved through gifts alone. It is enforcement problems that are the reason for the existence of quasi-credit: by establishing a direct link between what agents give today and what they expect to receive tomorrow, quasi-credit rewards giving over and above what pure gift giving can achieve. As a result, it is able to overcome some of the limitations imposed by participation constraints and thus raise efficiency (see also Ligon, Thomas and Worrall (1996)).

Many of the features of quasi-credit that have been noted by observers of rural Third World societies (e.g., Scott (1976), Popkin (1979), Platteau (1991), Basu (1986), Gluckman (1955)) are puzzling when quasi-credit is looked at as a regular market transaction. Treating quasi-credit as the equilibrium of a repeated risk sharing game helps explain many of them. First, there is no sense in which the interest rate on quasi-credit contracts clears the market: as Proposition III.7 demonstrates, the interest rate is indeterminate. This helps explain why so many Third World consumption loans between equals carry no explicit interest (e.g, Townsend (1994), Fafchamps and Lund (1999)) and why interest rates sometimes vary wildly between transactions in the same village and time period (e.g., Udry (1990)). Second, loan repayment is conditional on subsequent shocks; default and postponement are anticipated and implicitly accepted beforehand. This stands in constrast with regular credit contracts which are expected to be repaid in most if not all circumstances. Third, *access* to credit is the means by which mutual insurance is organized. Loans are therefore rationed: in order to get a loan, one must show sufficient need (e.g., Fafchamps and Lund (1999)). Quasi-credit at zero interest rate is not meant to be used for investment purposes. Townsend (1993), for instance, provides evidence that investment loans in Thai villages do carry an interest and are treated differently from consumption loans. Fafchamps and Lund (1999) provide similar evidence for the Philippines. Fourth, because repayment is only guaranteed by continued participation to the IRSA, quasi-credit loans are unlikely to be made to someone whose expected future contribution to or gain from risk sharing is low. Transactions are thus not anonymous but entirely personalized: that i got a loan from j does not mean that k can get a loan from j.

Many of the transfers that appear in Proposition III.7 serve to offset credit obligations. Does it matter how these transfers take place? As Proposition III.8 demonstrates, the answer is yes: more efficiency in risk sharing can be achieved if debt can be postponed and not simply forgiven. Let A and B be as in Proposition III.7. Let C stand for the set of subgame perfect equilibria that can be achieved when debt cannot be rescheduled, that is, when $W(y, w_0) = W(y, w_1)$ for all y, w_0 and w_1 (A6). Then we can show that:

Proposition III.8: $A \subseteq C \subseteq B$.

That A may $\subset C$ is illustrated by the example given above, in which debt could not be postponed. The example can easily be expanded to show that debt rescheduling increases the reward for giving and thus reduces the discount rate required for the participation constraint to be satisfied, in which case we would have $C \subset B$ as well. This is left as an exercise for the reader. Proposition III.8 thus provides a possible explanation for why debt repayments often are postponed and rolled over instead of being simply forgiven (e.g., Udry (1990), Fafchamps and Lund (1999)).

Although many consumption credit transactions remain informal, some, like loans from money-lenders for instance, are somewhat more formal and often include a credible threat to seek external enforcement. Since the respect of debt repayment obligations is more easily verifiable by an outside party than the state of nature on which transfers τ_s depend, there are good reasons to suspect credit contracts to be enforceable even when mutual insurance obligations are not. We now show that the possibility of external enforcement, even if imperfect, helps risk sharing. The reason is that the effectiveness of quasi-credit is limited by the requirement that credit obligations w_t^i be self-enforcing: the more debt an agent accumulates, the more tempting it is for him or her to defect from the IRSA. These limitations are reduced if credit contracts can be externally enforced.

Assume that a credible external enforcement technology exists for credit contracts. If a debtor defaults on a loan, penalties can be inflicted. Let the expected discounted utility cost of these penalties be an non-de<u>c</u>reasing function $P(w_t^i)$. Let us also assume that penalties are finite, i.e., that $\lim_{w \to \infty} P(w) = \overline{P} < \infty$. The participation constraint for risk sharing can then be rewritten:

$$U_i(\pi_{s'}^i) - U_i(c_{s'}^i) \leq \sum_{u=1}^{\infty} \delta^t E[V(c_{s,u}^i)] - \frac{\delta}{1-\delta} EU_i(\pi_s^i) - P(w_t^i) + A_i \tag{79}$$

The only difference with equation (78) is $P(w_t^i)$: the use of credit contracts inflicts heavier penalties on agents who defect on their risk sharing obligations. Let D be the set of perfect equilibria supported by externally enforceable credit contracts as defined in equation (79). Since harsher punishments support more risk sharing, we get:

Proposition III.9: $B \subseteq D$.

External enforcement can only improve efficiency if explicit, enforceable contracts are combined with implicit risk sharing arrangements. Pure credit alone would not achieve the same result. Furthermore, external enforcement helps only if if the penalty for default $P(w)$ is finite. If contractual default is never allowed, individuals never borrow more than the annuity value of their minimum income. If their minimum possible income is zero, they never become net borrowers, however small the probability of a zero income is (e.g., Zeldes (1989), Carroll (1992), Fafchamps and Pender (1997)).[63] In this case, consumption smoothing can only be achieved through pure gift giving. Zame (1993) demonstrates that even contingent contracts cannot, in general, be efficient unless penalties for default are not too high, that is, unless contract repudiation is tolerated in certain circumstances. Allowing debt obligations not to be met in certain cases makes credit contracts resemble quasi-credit: they *de facto* mix credit with insurance. Proposition III.9 complements these earlier results by showing that insurance can

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[63] The only exception is when an agent's utility without the loan is already $-\infty$. Desperation can lead agents to borrow under threats of extreme punishment if they do not repay.

in turn be made more efficient by externally imposing penalties for the non-respect of credit contracts.

Proposition III.9 opens a large gray area between non-market transactions -- the income pooling arrangements discussed in Chapter I -- and pure market transactions -- contracts that are enforced exclusively through $P(w_t)$. Most real world transactions probably stand somewhere in between. There often is an implicit arrangement between parties to renegotiate the terms of the explicit contract, either by forgiving part of the debt or by postponing contractual compliance (e.g., Kranton (1996), Fafchamps (1996), Fafchamps (1996)). In this gray area, transactions share some of the characteristics of quasi-credit: rationing according to need; a certain indeterminacy in interest rates, solved either through individual variation in interest rate or by fixation around a focal point; *de facto* conditional loan repayment; and personalized, repeated transactions. They also may display characteristics that are associated with well functioning markets: limits on the individual variation of interest rates; mobility between sources of finance; free access to credit within a certain range. Although contract enforcement issues naturally raise a host of information asymmetries problem, Proposition III.9 suggests that enforcement alone can account for many observed features of credit markets (e.g., Stiglitz and Weiss (1981)) even in the presence of perfect information (see Fafchamps (1996), Fafchamps (1996)) for illustrations).

4.2 Information asymmetries

For long-term relationships to mitigate commitment failure, shocks affecting members of the risk sharing group must be observable by others. If not, members may be able to file false ’insurance claims’ and abuse the system. Fafchamps (1992) discusses how informal risk sharing might be affected by information asymmetries. He argues that the observability of income and wealth are essential for risk sharing to operate efficiently. Short of that, parties to an informal risk sharing arrangement must rely on imperfect signals and blunt sanctions. Efforts by poor rural societies to minimize the efficiency loss from imperfect information include:

- the lack of privacy, so that consumption can easily be observed;
- the moral condemnation of greed, that is, the dissimulation of wealth;
- the redistribution of productive assets (e.g., land) instead of consumption to minimize shirking.
- the provision of partial or catastrophic insurance only to minimize moral hazard

These features are by and large in line with observations (see Fafchamps (1992) for details).

The organization of risk sharing as networks of friends and relatives can similarly be understood as a way to economize on monitoring by decentralizing the system. Using original data from the Philippines, Fafchamps and Lund (1999) show that efficient risk sharing is not achieved at the village level and that networks play an important role in the sharing of risk. Further evidence on the role of friends and relatives in coping with risk can be found in the sociological and anthropological literatures, as well as in the literature on remittances (e.g., Lucas and Stark (1985)). Rosenzweig and Stark (1989) shows that marriages in part responds to households’ desire to form risk sharing bonds with other families in distant villages, hence suggesting that the formation of networks is itself endogenous to the risk coping process.

CHAPTER IV. RISK AND DEVELOPMENT

So far we have discussed how the rural poor deal with risk. We now focus on the relationship between rural poverty, risk, and economic development. The poor's inability to deal with risk does not only have welfare effects. It also reduces a society's capacity to accumulate, innovate, and develop. Risk thus contributes to creating a vicious circle of poverty. A proper understanding of the interaction between risk and poverty is essential to identify the obstacles to growth and development in poor rural societies. This chapter discusses several mechanisms through which poverty and vulnerability hurt growth.

Section 1. Nutrition and Human Capital

It has long been recognized that poverty is detrimental to the accumulation of human capital, and in particular to health, nutrition, and education. It is hardly novel to point out that the poor are malnourished. In fact, malnutrition is often used as an indicator of poverty, if not synonymous with it, and the provision of adequate nutrition is at the core of many efforts to combat poverty (e.g., The (1986)). In this section we revisit some of these issues and reinterpret them in relation to risk and risk coping strategies. Given the voluminous literature on these issues, we limit ourselves to a brief survey of the salient themes.

1.1 Fertility and infant mortality

In Chapter I we stressed that health risk is one of the major risk factors faced by the rural poor and that it disproportionately affects children. As a result, child mortality is high in most rural areas of the Third World, although it has been steadily declining thanks to vaccination campaigns and the provision of simple health care. Because the poor rely on their children for old age support, it has been argued that the poor compensate for high infant mortality by having more children in order to ensure a minimum number of surviving offspring (e.g., Nugent (1985), Nugent (1990), Datta and Nugent (1984), Rosenzweig and Wolpin (1985) as well as Chakrabarti, Lord and Rangazas (1993) and the references cited therein). High fertility, in turn, raises population pressure both within the household and in society at large, leading to a Malthusian trap both at the individual and the aggregate level.

There are several problems with this line of argument. First the logic of the story is partly defective. If people have children to ensure old age support, then the main driving force behind increased demographic pressure ought to be adult mortality, not child mortality. The reason is that, while adult mortality cannot be 'corrected' *ex post,* most infant and child mortality can.[64] To see why, consider the following hypothetical example. Suppose that adult mortality is zero but child mortality is 250/1000, i.e., a child has 25% chance of dying before the age of 5. A couple has calculated that, by the time they reach old age, they need two surviving offspring, no more, to take care of them. Clearly, the optimal strategy is for the couple to have two children at the outset and to wait to see what happens. Only if one of the kids dies before the age of 5 is it optimal for the couple to have another child, and so on until two children reach the age of 5. Except for some possible overshooting if menopause is reached before two surviving kids have been obtained,[65] this strategy will result in two surviving children. Of course, in this stylized example the realized fertility rate of the couple depends on

[64] Infant mortality is traditionally defined as the proportion of children who die before the age of one; child mortality is the proportion of children who do not attain the age of 5.

[65] As the couple approaches menopause without two children aged 5 or above, the possibility arises that all or one of the two children might die after they can be replaced. In this case, the couple might choose to overshoot whenever it approaches menopause without two offspring aged 5 or above. As a result of

child mortality: any child death is matched by an additional birth (e.g., Bongaarts and Cain (1981)). But the number of surviving children -- and thus population pressure -- is not sensitive to the child mortality rate.[66] Only an increase in *adult* mortality would induce risk averse parents concerned with old age support to compensate by having more children, resulting in an average number of surviving adults greater than two, and thus in an increase in population pressure. As this example illustrates, infant and child mortality are very unlikely to lead to a Malthusian trap; adult mortality, however, can.

Second, the empirical evidence on Malthusian traps is largely inconclusive (e.g., Dasgupta (1995) and the references cited therein). For one thing, currently developed countries managed to dramatically expand their population while growing rapidly. In contrast, there are several examples of developing countries or regions that drastically reduced fertility rates and population growth without noticeable impact on growth (e.g., Kerala, Sri Lanka). Recent work by demographers suggest that fertility behavior might best be understood in terms of net fertility, that is, in terms of the number of surviving children per women. There is indeed ample historical evidence that net fertility is responsive to perceived income opportunities: when they abound, as was the case historically in the Americas, net fertility rises; when they are stationary, net fertility is by and large just sufficient to ensure a constant population (e.g., Lee (1987)). If this interpretation is correct, increases in net fertility should be seen mostly as a response to perceived increases in income opportunities such as those generated by the opening of a land frontier or by urbanization and industrialization (e.g., Wilson (1995)). This issue deserves more investigation.

Third, the micro evidence on the relationship between poverty and fertility is also largely inconclusive (e.g., Dasgupta (1995)). Empirical evidence suggests that in poor villages the relationship might well run in a direction opposite to what is normally assumed, wealthier households having more children not less. This appears to be the case whenever children are an important source of labor for cultivation and livestock herding: household with more abundant resources are induced to have more offspring because the children can participate to farm work and are more easily provided for (e.g., Grootaert and Kanbur (1995), Basu and Van (1996)). Only when opportunities arise to significantly raise the expected earnings of children through better education and nutrition does a trade-off arise between the quantity and quality of the children a couple might optimally have. If the returns to human capital are sufficiently high *and* adult mortality sufficiently low, investing in a small number of highly educated and well nourished children becomes optimal (e.g., Becker, Murphy and Tamura (1990)). The high cost of schooling might, however, preclude the poor from investing in child quality, leaving them the only option of investing in quantity -- at least as long as they have enough land and livestock to provide for them. This might lead to a two-tiered situation, in which wealthy, urban based, market oriented parents invest in a few well educated kids, rural based, subsistence oriented invest in many uneducated kids, and low income households invest in children hardly at all. We revisit these issues below when we discuss human capital. For the time being, let us simply point out that the micro evidence on the relationship between poverty and fertility does not support a general monotonic relationship between rural poverty and high fertility.

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overshooting, the average number of surviving offspring might slightly exceed two, but not by much because the overwhelming majority of couples would have two surviving offspring by the time they reach menopause.

[66] Except just before menopause, when couple without two surviving children may optimally choose to overshoot.

Finally, many rural societies have invented institutional response to the need for old age support. Although it is possible to find in poor villages elderly people without descendents who live in deep poverty, it is erroneous to assume that old age support is only ever provided by direct descendents. In many cases, the extended family is involved as well. Individuals without descendents can anticipate their need for old age support by cultivating the goodwill of other relatives. In other words, the extended family provides a framework within which replacements for missing offspring can be found. Many societies formalize offspring replacement through the practice of adoption, thereby strengthening the bonds between a childless couple and its adopted offspring. The very existence of these institutions -- extended family and formal adoption -- suggest that poor rural societies have devised insurance mechanisms against the loss of offspring, thereby reducing the need for excess fertility.

1.2 Nutrition, health, and vulnerability to shocks

Without doubt the most dreadful consequence of poverty is that income and health shocks often lead to early death. This is true for children, as discussed in the above subsection, but also for adults and the elderly. Early demise may follow from someone's inability to command sufficient food, clothing, and shelter for day-to-day survival, or from someone's incapacity to receive proper medical care to deal with a treatable disease. Famines are examples of shocks that affect an entire group's capacity to provide for itself. In practice today, famines and other emergency situations often result or are seriously aggravated by warfare and civil unrest, as the example of the 1984 Ethiopian and Sudanese famines illustrate. Epidemics such as malaria, measles, or tuberculosis -- the worst killer diseases in Sub-Saharan Africa -- are examples of health shocks that affect many individuals in the same population.

There are long lasting effects of shocks other than death. Stunting, a serious deficit in height, is the result of improper nutrition during childhood. Children who are raised in households subject to severe even if temporary shocks, and who consequently receive insufficient food, may suffer permanent consequences in the form of reduced height. In addition, stunting is generally believed to be correlated with poor health and to raise the risk of complication during pregnancies (see, however, Payne and Lipton (1994) for a dissenting opinion). Even if stunting is not associated with poor health, it nevertheless reduces an individual's body size and strength. Indeed, short size has empirically been associated with lower productivity in farming and livestock activities (e.g., Foster and Rosenzweig (1993), Foster and Rosenzweig (1996), Fafchamps and Quisumbing (1998), Fafchamps and Quisumbing (1998)). Disease can similarly reduce someone's ability to cope with subsequent health shocks, especially if left untreated. Consequently, inability to cope with health risk at a moment in time leads to increase vulnerability in the future.

Poor populations subject to repeated shocks have a high incidence of stunting and high physical vulnerability to diseases (e.g., Payne and Lipton (1994)). These deficiencies reduce the population's capacity to produce and accumulate (e.g., Fogel (1990)), hence making it difficult to get itself out of poverty. Although one should be careful not to fall victim to economic determinism -- after all, all countries were once poor, including the rich of today -- poverty makes development difficult in ways that are hard to anticipate for well fed, healthy development experts in the field and project managers in their offices.

By increasing the vulnerability of individuals or groups to health and income shocks, poverty leads to higher morbidity and mortality and a higher incidence of stunting, chronic poor health, famines, and destitution. These undoubtedly have an adverse effect on the stock of human capital and talent in a given society. They also disrupt families and make it difficult for children to receive the nutrition and schooling they need. None of these observations are new, but they serve to emphasize that poverty by itself seldom leads to death or disease. Except in cases of extreme destitution, the proximate cause of death or poor health is always an identifiable income or health shock. It is not poverty that kills or incapacitates, but the vulnerability to shocks that is generated by poverty.

From this realization, it follows that welfare can be improved dramatically by decoupling poverty from vulnerability. This is important because eradicating poverty is a difficult and lengthy task. Realizing that the most visible and least desirable consequences of poverty can be eliminated or at least minimized without eliminating poverty itself opens new avenues for intervention.

1.3 School attendance and risk

Since the seminal work of Schultz (1961), the role that human capital, and especially education, play in the development process has received a lot of attention (e.g., Mankiw, Romer and Weil (1992), Barro and Sala-i-Martin (1992)). Microeconomic empirical work suggests that, in poor rural areas, the returns to education are highest in non-farm activities (e.g., Yang (1997), Fafchamps and Quisumbing (1998), Jolliffe (1996)). Some evidence indicates that it might also be significant in farming, especially when new technologies are introduced (e.g., Lockheed, Jamison and Lau (1980), Phillips (1987)). The poor’s capacity to invest in schooling is thus an important factor of long-term success in the development of rural areas of the Third World.

Yet, not only do poor rural households find it hard to stay well nourished and healthy, they also have to struggle to put their children in school. Money for school fees, books, and uniforms is hard to come by. Furthermore, children’s time is valuable because they often contribute to household work, participating to livestock and farm activities as well as to household chores (e.g., Grootaert and Kanbur (1995), Fafchamps and Quisumbing (1998)). Since borrowing on future income is difficult if not impossible in virtually all economies -- but especially in those where adult mortality is high -- poor parents cannot always afford to send their children to school. This depresses the human capital of their offspring and tends to replicate their own poverty across generations.

Recent empirical work has refined the above picture by bringing out the role that shocks play in school attendance. Jacoby and Skoufias (1995) and Sawada (1997) have indeed shown that children’s propensity to join school and to drop out of school responds not only to chronic poverty but also to transient shocks. The evidence provided by Sawada (1997) even indicates that the effect of transitory income shocks on school entry and drop out rates is higher than that of permanent income. This result suggests that households’ incapacity to handle temporary shocks in income is a more important determinant of school attendance than poverty itself. Again, this finding has important policy implications. It suggests that programs aimed at helping poor parents handle emergencies may be more cost effective in keeping poor children in school than program aiming either at reducing poverty itself or at reducing school costs for the poor as a whole. It might be more cost effective to reduce school fees selectively for those parents who face temporary difficulties.

Section 2. Risk and Technological Innovation

We have seen that one of the ways by which the rural poor cope with risk is by choosing activities and techniques of production that keep income variations to a minimum. One potential consequence of such a strategy is that the poor will resist technological innovations that raise the mean and variability of income at the same time. This simple observation has received a lot of attention and resistance to risk taking has been blamed for many of the failures to induce poor villagers to adopt technologies developed for them (e.g., Feder, Just and Zilberman (1985), Eicher and Baker (1982))

This section revisits these issues and briefly summarizes the implications of risk aversion for technology adoption and extends it to market risk. It also reviews the available evidence for and against risk aversion as an impediment to innovation and market participation. We begin with a discussion of risk aversion and production choices. We continue with a review of the trade-off between specialization and diversification. Next, we debate commercial farming and the reliance on the market in poor rural areas. We conclude with a brief discussion of technological uncertainty and learning.

2.1 Production choices and risk

We have seen in Chapter II that one way for poor farmers reduce the income risk they face is to make production choices that reduce the variance of their net income. As Sandmo (1971) elegantly demonstrated, one effect of risk aversion on production choices is to reduce effort. To see why, consider a producer with indirect utility $V(y, p)$ where p is a vector of consumption prices that, for the moment, we assume constant. The value of output is stochastic and is written $\tilde{\theta} x$ where $\tilde{\theta}$ is a combination of multiplicative yield risk and output price risk. The producer faces a cost function $C(x)$ which is increasing in x and concave, i.e., with decreasing returns to scale (as would be the case if there is a fixed factor). Assuming that no insurance is available and that sufficient funds are available to finance production, the decision problem of the producer can be written:

$$\underset{x}{Max}\ E\,[V(y, p)] \tag{80}$$

subject to

$$y = \tilde{\theta}\, x - C(x) + U \tag{81}$$

where U denotes unearned income (e.g., remittances, pension, rental income). The first order condition is:

$$E\,[V'\,(\tilde{\theta} - C'(x))] = 0 \tag{82}$$

If the producer is risk neutral, utility is linear in income, which implies that V' is constant. The first order condition then boils down to:

$$C'(x) = \mu \tag{83}$$

where μ is shorthand for $E[\tilde{\theta}]$. In this case, optimality requires that marginal cost equal expected marginal revenue. A similar result is obtained if the producer is risk averse but complete insurance is available, so that production decisions are decoupled from producer preferences (see Chapter II, Explicit Risk Sharing).[67]

However, if the producer is risk averse, then expected output x will be lower than it would be if complete insurance were available or if the producer was risk neutral. To see why, note that, since $V(y,p)$ is concave in y when the producer is risk averse,

[67] Note that even if perfect insurance markets exist, complete insurance need not exist: the economy might be subject to collective shocks it cannot insure against. In this case, residual risk remains and producers are predicted to behave in a risk averse manner even though insurance markets are perfect (e.g., Fafchamps and Kurosaki (1997)).

$V'(y,p) \leq V'(E[y],p)$ whenever $\tilde{\theta} \geq \mu$, and vice versa. Consequently,

$$V'(y,p)(\tilde{\theta}-\mu) \leq V'(E[y],p)(\tilde{\theta}-\mu) \tag{84}$$

for all $\tilde{\theta}$. If inequality (84) is true for all $\tilde{\theta}$, then we can take expectations of both sides and write:

$$E\,[V'(y,p)\,(\tilde{\theta}-\mu)] \leq V'(E[y],p)\,E[(\tilde{\theta}-\mu)] = 0 \tag{85}$$

where the right hand side of the inequality is zero since, by definition, $\mu \equiv E[\tilde{\theta}]$. Now, from the first order condition $E[V'(y,p)\,p] = E[V'(y,p)\,C'(x)]$, we can write:

$$E[V'(y,p)(p-\mu) = E[V'(y,p)\,(C'(x)-\mu)] \tag{86}$$

Combining equation (86) with inequality (85) we get:

$$C'(x) \leq \mu \tag{87}$$

Since the cost function is concave, the value of x that satisfies inequality (87) must be smaller than the value of x that satisfies the equality $C'(x) = \mu$. Consequently average output x is smaller without complete insurance than with it. Sandmo (1971)'s result implies that producers without perfect insurance will underproduce, and hence underinvest in production and underpurchase inputs relative to what would be dictated by the maximization of expected profit. The poorer producers are and the less access they have to insurance, the more concave $V(y,p)$ will be, and the lower x will, in general, be.[68]

Sandmo (1971)'s contribution has been widely received among economists working on technology adoption by poor farmers as a convincing story to explain resistance to technological innovation and underinvestment in production enhancement. If one abstracts from the purchase of new technologies and investment in durable productive resources, the evidence does not, however, strongly support Sandmo (1971)'s conclusion: poor rural household do not appear to systematically underproduce given their productive resources and the absorptive capacity of the market for agricultural products (e.g., Walker and Ryan (1990)). This should not be surprising. After all, at some fundamental level, Sandmo's result is counterintuitive: if people are poor and are concerned about survival, the solution is clearly not to underproduce. So what is it about Sandmo's result that is misleading?

One issue is the assumption that consumption prices are constant. We get back to it below, but it is not central to our critique of the common interpretation of Sandmo's result. More important is Sandmo's assumptions about how output is produced and how production is financed. The model presented above makes two fundamental -- though hidden -- assumptions. First it assumes that all inputs are marketed so that only their market value, summarized in $C(x)$, matters. If, in contrast, output is produced primarily with labor and that a complete labor market does not exist, then Sandmo's model is inappropriate. If the choice facing farmers is enjoy leisure now and starve later, or produce now and survive, then most farmers will choose to produce. Furthermore, the higher the risk they face, the harder they are likely to work. This can be formalized by rewriting the above model as is Fafchamps (1993):

$$\underset{l}{Max}\, E[V(y,\ p,\ l)] \tag{88}$$

subject to

[68] Although this statement is intuitively appealing, more stringent conditions about the curvature of the utility function are in fact needed for it to be true. See for instance Diamond and Stiglitz (1974), Dreze and Modigliani (1972), Dardanoni (1988).

$$y = \tilde{\theta}\,(T - l) + U - C \qquad (89)$$

where l stands for leisure, T for total time endowment, and C for minimum consumption. We have assumed for simplicity that output is linear in labor. The utility function $V(y, p, l)$ can be understood as the result of a two-step optimization process: in the first period the producer chooses how much to work -- and thus how much leisure l to consume; in the second period the producer chooses how to spend earned and unearned income on consumption. Solving for the second period optimization process yields the conditional indirect utility function $V(y, p, l)$ (see Epstein (1978), Epstein (1980) for details).

The first order condition of the above optimization problem is:

$$E[V_y \tilde{\theta}] = E[V_l] \qquad (90)$$

From equation (90), straightforward comparative statics yields:

$$\frac{d\,l}{d\,C} = \frac{E[V_{yl}] - E[V_{yy}\,\tilde{\theta}]}{SOC} \qquad (91)$$

Since the second order condition is necessarily negative at an interior optimum and since V_{yy} is negative whenever the producer is risk averse, we see that a sufficient condition for leisure consumption to decrease as the minimum consumption requirement C increases is that $V_{yl} \geq 0$, i.e., that the marginal utility of leisure is non-decreasing in non-leisure consumption y -- a natural assumption if leisure is a normal good. In fact, it is even possible for the marginal utility of leisure to be decreasing in y and still have leisure decreasing in C provided that the producer is sufficiently risk averse. Translated in english, this result implies that poor villagers will produce more, not less, if they face a higher risk of starvation.

A second hidden assumption in Sandmo's model is that input costs can be financed with output: Sandmo's model indeed contains no additional liquidity or credit constraint requiring that:

$$C(x) \leq B \qquad (92)$$

where B is the amount of cash the producer has access to. This is akin to assuming either that credit is available to finance all input purchases, or that producers are sufficiently wealthy to finance these costs from their own pocket. When inputs are not purchased but provided directly by the household, such as owned land, family labor, manure from own livestock, and draft power from own animals, constraint (92) is unlikely to be binding. But when farmers are presented with new technologies for which up front cash outlays are required, such as fertilizer, improved seeds, animal traction equipment, irrigation pumps, and the like, these conditions are unlikely to be satisfied and constraint B is likely to bind for poor farmers. Consequently, poverty coupled with credit market imperfections constitutes a working hypothesis for why poor farmers do not adopt new technology that is more intellectually appealing than aversion toward risk.

There is, however, another modification of Sandmo's model that is quite relevant in practice, namely, one emphasizing bankruptcy risk. Sandmo's model implicitly assumes that production costs can always be financed out of output or out of wealth/unearned income U. Indeed, for Sandmo's model to be rigorously correct, one must assume either that consumption can become negative -- an impossibility -- or that income and U are *always* sufficient to cover $C(x)$, i.e., that the producer never goes bankrupt. These conditions are seldom satisfied in the case of poor farmers considering spending cash on a new agricultural technology. Even assuming that credit is available to finance input purchases, poverty still means that there is little wealth or unearned income to pay the debt in case of crop failure. What happens to a producer without enough assets to pay the debt then determines its willingness to borrow money to purchase inputs.

To begin with, if lenders insist on full payment under all circumstances, they will refuse to lend to a producer who does not already have enough assets to purchase the inputs. In other words, if lenders refuse to bear any default risk, poor borrowers will *de facto* be rationed out: since they cannot promise to repay for certain, they cannot enter into a contract that requires full repayment in all circumstances. Only producers who already have assets can borrow; borrowers can never hold a negative net wealth (e.g., Carroll (1992)). Notice that rationing arises without any imperfect information; it is simply a consequence of the fact that producers cannot give what they do not have.

Next, suppose that default is allowed but that lenders insist on recouping as much of the amount borrowed as possible. In this case, when the value of crop output falls below the value of the debt, the producer is forced to consume nothing.[69] To capture the fact that consuming nothing or close to nothing is a very unpleasant occurrence, let the utility of zero consumption be a large negative number, say, $-\underline{H}$. Let the cumulative distribution of random income y be written $F(y)$ and let the support of y be $[0, \bar{y}]$ with $\bar{y}$ possibly $+\infty$. The producer's optimization problem now is:

$$\underset{x}{Max}\ -\underline{H}\ Prob(y \leq C(x)) + E[V(y,p) \mid y > C(x)] \tag{93}$$

subject to

$$y = \tilde{\theta}\, f(x) - C(x) \tag{94}$$

For notational simplicity we have assumed that the interest rate is 0, so that debt repayment equal $C(x)$. To focus on debt repayment, unearned income U is assumed to be 0.

The above model is not very different from Sandmo's. All it does is to bring into the open the probability of bankruptcy -- $-\underline{H}\ Prob(y \leq C(x))$. The first order condition becomes:

$$-\underline{H}\ C'(x)\ \frac{\partial\, Prob(y\ ,= C(x))}{\partial\, x} + E[V'(y,p)(\tilde{\theta} - C'(x)) \mid y > C(x)] = 0 \tag{95}$$

Note that if $f(0) = \bar{y} > 0$, that is, survival can be attained without purchased input x, then only if $C(x) = 0$ does the first term -- the effect of input expenditures on the probability of bankruptcy -- disappear.[70] This is different from Sandmo's model because it implies that even if the producer is risk neutral, i.e., if $V(y,p)$ is linear in y, the producer still behaves in a risk averse manner, i.e., refrains from using the amount of inputs x that maximizes expected profits. The reason is that the producer fears bankruptcy. In fact, if $-\underline{H} = -\infty$, it is optimal for the producer not to purchase any input x at all *even if* lenders are willing to lend.

The difference between Sandmo's general result that risk averse producers purchase less inputs and our conclusion that producers who fear bankruptcy purchase less inputs might appear minute. In fact, however, it is crucial for policy design. In our model, what producers are worried about is not so much variations in income but the probability that realized income may be so low as to endanger the survival of the household. If this is a fair characterization of poor producers' fears about purchased inputs, it implies that if a mechanisms can be found that provides credit AND eliminates the risk of bankruptcy, poor producers will be willing to

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[69] Or close to nothing if, as is often the case by law, creditors cannot foreclose on everything the debtor has.

[70] To be fully rigorous, we need another technical assumption, namely that the distribution of θ has not mass point at 0.

purchase cash inputs. Such mechanisms in fact exist. Here are three examples.

The first example is that of sharecropping. In many sharecropping contracts it is common for the landlord to provide some of the cash inputs and to take part of the output as compensation (e.g., Braverman and Stiglitz (1986), Shaban (1987), Krishnan (1996)). This contractual arrangement does not eliminate risk for the producer, but it provides credit: the inputs are given at the beginning of the cropping season, they are repaid at harvest. Furthermore, it eliminates bankruptcy risk: if crops fail, nothing is paid.[71] In spite of initial fears regarding landlords' willingness to invest in new technology (e.g., Bhaduri (1973)), the bulk of the evidence now indicates that sharecropping is an effective way of delivering input credit to producers (e.g., Braverman and Stiglitz (1986), Gavian and Teklu (1996)).

The second example is taken from the input delivery practices of agricultural marketing boards during and after the colonial period in Sub-Saharan Africa.[72] It was common practice for agricultural marketing board to provide farmers with agricultural inputs at the beginning of the season and to recoup the cost of these inputs at harvest time. Since many of these marketing boards had a monopsony on the cash crop they were responsible for, producers could not abscond from the credit they had received by selling to someone else.[73] This method of recouping input credit *de facto* meant that farmers were responsible for input costs only up to the value of their cash crop output. The method by which this was accomplished varied (sometimes input costs were simply deducted from a pan-territorial output price, sometimes villagers as a group were held collectively responsible for the payment of inputs used in their village) but the end result was the same: in case of crop failure, producers paid nothing. The simple fact that producers complained bitterly any time this principle was violated serves to stress its important.

The third example comes from contract farming. In many ways, contract farming resembles what agricultural marketing boards do: they provide affiliated growers with seeds and inputs and promise to purchase all or part of their output, at which time inputs are paid. The crop itself serves as collateral for the inputs and the contractor often has the right to harvest the crop to recoup the cost of the inputs.[74] Although in theory contractors could seek to recover all input costs on growers' assets in case of crop failure, they hesitate to do so not to antagonize their growers. So, *de facto,* growers pay nothing in case of crop failure.

These three input delivery schemes have two features in common: payment at harvest, and no payment in case of crop failure. Otherwise the details of input repayment vary a lot from one example to the next -- in the sharecropping example, costs are paid as a share of harvest; in the agricultural marketing board example, costs are deducted from the output price or paid jointly by villagers; in contract farming, costs are deducted from the value of the harvested crop. That much variation suggests that these contractual details are less important than the two principles listed above. Similar principles can be successfully applied to other technology delivery schemes, such as animal traction equipment.[75]

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[71] In fact, there is evidence that even when harvest is poor although not zero, tenants are also dispensed to share output with the landlord (e.g., Singh (1989), Dutta, Ray and Sengupta (1989)).

[72] Cotton marketing boards in West Africa are a good illustration of these practices (e.g., Roberts (1996)).

[73] Although some invariably tried, especially nearby porous borders like that between Senegal and Gambia.

[74] In fact, certain contracts stipulate that harvesting is done by the contractor itself.

[75] In this case, repayment of the equipment is spread over several years and producers get a repayment holiday if they can show they were hit by an adverse shock (e.g., ILO (1984)).

2.2 Diversification and specialization

In the preceding sub-section we have argued that aversion toward risk and a desire to smooth consumption are not, by themselves, a convincing explanation for poor farmers reluctance to purchase new inputs. Credit constraints and concerns about bankruptcy are probably a more accurate way of thinking about the obstacles poor farmers face when adopting agricultural practices that require the use of purchased inputs. In this section, we argue that risk aversion is an excellent explanation for another often observed feature of technology adoption by poor farmers, namely, partial adoption.[76]

The attractiveness of partial adoption follows from the portfolio argument discussed in Chapter II: if the incomes generated by different technologies are only imperfectly correlated, producers can reduce the total variation of their aggregate income by combining several crops and technologies on their farm. In fact, if crops and techniques of production are characterized by constant returns to scale, the portfolio argument would dictate that any risk averse farmer ought to plant all the crops and varieties and use all the techniques of production that are not stochastically dominated by others.[77] Thus, if new technologies are disivible, farmers' desire to smooth consumption should make them more willing to adopt *more* new technologies than if they were risk neutral. Put differently, poor farmers' desire to smooth consumption favors -- not hinders -- the adoption, albeit partial, of new technologies as long as they are divisible. In contrast, risk neutral producers would concentrate on the single crop or technology, whether new or old, which has the highest expected return. Based on this reasoning, and abstracting from the issue of purchased inputs discussed in the previous subsection, if consumption smoothing is the main determinant of technology choice, risk averse farmers should adopt any new technology that comes along provided its risk profile differs from what they currently cultivate. On the other hand, risk neutral farmers should only adopt the new technologies that yield a higher return. Unless one is willing to assume that the new technologies proposed to Third World farmers are always superior to what they currently grow -- a proposition that is doubtful given the quality of what often comes out of agronomic research stations in poor countries -- one would expect risk averse farmers to be on average more receptive than risk neutral farmers, not less, to new technology. Put different, the probability that a producer would adopt an arbitrary new technology on at least part of its fields is higher for risk averse than risk neutral farmers as long as the new technology does not require large cash expenditures up front.

Of course, this conclusion holds only if the new technology is divisible, that is, if it does not benefit from returns to scale. In case the technological innovation has fixed costs (e.g., tractors) or requires a reorganization of production that is not favorable to diversification (e.g., large irrigated scheme), then the desire to smooth consumption clearly operates against adoption. The reason is that the desire to diversify dilutes some of the gains from adoption. By the same token, even if adoption takes place, poor farmers diversification strategy still works against full specialization, hence implying that the full gains from innovation are not captured. Partial adoption is the rule, which dilutes the gains not only from innovation but

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[76] By partial adoption we mean adoption of a crop or technology over only a portion of the farm or for some of the time. We do not mean the adoption by farmers of only certain parts of a package that is proposed to them. Debundling by farmers of ready-made technological packages is a sign of experimentation and should be encouraged.

[77] More precisely, if N moments are required to fully characterize crops' distribution function and no crop/technique is stochastically dominated by other crops or combination of other crops/technique, then farmers ought to plant N crops/use N techniques.

also from learning about the new technology. The same can be said of income diversification strategies that encompass multiple farm and non-farm activities: by spreading their attention too thin, households fail to capture all the gains from specialization in a single activity. This is the price society pays for portfolio diversification.

To summarize, risk averse farmers' desire to diversify their portfolio of crops and activities has two opposite effects on technology adoption. On one hand it makes them more receptive to new technologies that have a different risk profile, hence favoring adoption. On the other hand, it makes them less willing to specialize in a single activity or crop, even if it generates a higher income on average. Reluctance to specialize, in turn, reduces the gains from adoption and hinders it, particularly if the new technology benefits from increasing returns to scale. One should thus not blame the desire to smooth consumption for non-adoption of divisible technologies; risk aversion should only be blamed for partial adoption. An immediate corollary is that if a divisible technological innovation, such as an improved seed or chemical fertilizer, is not adopted at all by poor farmers, one should first look towards credit constraints and fear of bankruptcy as likely explanations, not toward a desire to diversify.

2.3 Technological uncertainty and learning

There is another type of uncertainty that is generated by new technology, namely, uncertainty regarding its income distribution. When a technical innovation is introduced in a new environment, it is typically unclear how it will perform and interact with local conditions. Experimentation is required to assess the probability distribution of the new technology. Some experimentation is typically undertaken by research organizations who then disseminate the results via extension agents. But in practice, farmers often feel the need for additional experimentation to investigate how the new technology interacts with their other activities and whether it performs in local conditions as advertised by extension agents. They also need to learn how to use the new technique.

This process of learning and experimentation is costly and time consuming. The question then arises of who is more likely to undertake this process, and whether poverty and risk aversion hinder it. It has been argued that poor risk averse farmers are unlikely to experiment because of the risk associated with it. The arguments presented in the previous sub-section indicate that this intuition is partly misleading. The desire to diversify ought to make poor risk averse farmers quite willing to experiment on a small scale. The first reason is that, since risk averse farmers are more likely to adopt a new technology (see above), they are also more likely to find experimentation attractive. The second reason is that experimentation itself is a form of risk diversification, and thus ought to be perceived as attractive as long as it can be undertaken on a small scale and does not raise any serious financial concerns. One would therefore expect even the poorest of farmers to experiment with new seeds on tiny parcels. If this does not take place, other explanations must be sought, as for instance mistrust in the information provided by extension agents and the widespread belief that extension agents promote ill-adapted technologies and agronomic practices.

There are, however, circumstances in which learning and experimentation are non-divisible. Migration to the city is an example of an experimentation process which is difficult to undertake on a small scale manner (unless it is sufficiently close to allow an easy commute) and thus may discourage very poor farmers. Only for sufficiently large households with good connections in the city do migration prospects become attractive -- unless of course the local situation has deteriorated so much that survival is a stake. These predictions are, by and large, consistent with observation.

The switch to animal traction is also largely non-divisible because draft animals have to be bought and trained and equipment has to be purchased before experimentation can begin. In these circumstances it is conceivable that a technology that is suitable ends up not being adopted because the learning process itself is too risky. This problem has typically been dealt with in two different ways. One approach has been to subsidize an otherwise comprehensive and rigid package. Success has been limited and debt recovery disappointing, hence precluding replication (e.g., Sargent et al. (1981), Eicher and Baker (1982)). A second approach, which seems to have worked better, has been to focus on very small-scale animal traction, e.g., using a single donkey instead of a pair of oxen, and to allow farmers to adopt only parts of the package, e.g., a cart or a weeder (e.g., Sargent et al. (1981), Jaeger (1986)). The arguments presented here suggest that the success of the second approach is probably due to the fact that it breaks the innovation into smaller components and brings experimentation within the reach of poor farmers.

Given the risk and potential benefits of large scale experimentation, one may wonder whether poor farming communities have found institutional ways of disseminating information about technology. After all, the results of experimentation and learning are at least partially non-rival in nature: once someone has figured out how to grow a particular crop in a particular environment, others can copy the technique without subtracting from the innovator's welfare.[78] Extension programs which have focused their technology dissemination efforts on large, more receptive farmers, have often justified their approach by implicitly assuming the existence of village institutions for the sharing of knowledge. If successful, early adopters, it was argued, would trigger copycats and the technology would trickle down to the entire community (e.g., Eicher and Baker (1982), Griliches (1988), Norman (1978), Foster and Rosenzweig (1995)). Recent work, however, casts some doubt on the existence of efficient channels for the dissemination of new technologies at the community level (e.g., Udry (1997) and personal communication from David Widawski, IRRI). Poor farmers seem to know much less about each others' production techniques than is often assumed and are often quite individualistic in their approach to farming. If technology information circulates at all among farmers, it appears to be in processed form and along networks of friends and relatives rather than in an efficient community-based manner. There findings, although preliminary, caution us not to put too much faith in the idea that non-divisibilities during learning and experimentation are irrelevant because the knowledge acquired by innovators circulates efficiently within the community.

Section 3. Commercial Crops vs. Subsistence Farming

In many cases, farmers cannot make full use of the technologies that are proposed to them without shifting, at least partially, to commercial crops and moving away from subsistence farming, if only to be able to pay for purchased inputs. Yet, agricultural censuses and household surveys often show that cash crops are grown principally by large farmers.[79] This section investigates the relationship between poverty, risk, and self-subsistence. A proper understanding of this relationship is indeed essential if the rural poor are to leave their cocoon and integrate the global economy.

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[78] Except for the possible reduction in purchase price, a problem which can, at least in theory, be solved by compensating -- the village equivalent of patents.

[79] See, however, Matlon (1977) for a counter example.

Several explanations have been proposed for the positive relationship between cash crop orientation and farm size. Some argue that farmers differ in their ability to sustain risk and that crop choices are but the consequence of differences in income risk aversion (e.g, Binswanger (1980), Shahabuddin, Mestelman and Feeny (1986)). Others invoke the presence of credit constraints, lumpy investments, technological differences, and differentials in relative factor costs across farms (e.g., Feder (1980), Feder (1985), Eswaran and Kotwal (1986)). These explanations contain elements of truth but they are not based on the fundamental difference between food crops and cash crops, namely that food crops can be consumed while cash crops cannot. A third explanation takes this difference as starting point and notes that in the absence of food markets, Third World farmers have to be self-sufficient in basic staples (e.g. de Janvry, Fafchamps and Sadoulet (1991)). In that case, farmers allocate land to cash crops only if their food security is guaranteed (Chapter II). This explains why large farmers are more cash crop oriented than are small ones.

The trouble with the latter explanation is that, in most poor villages today, food markets do exist. Yet it can be shown that, even when food markets are present, only wealthier farmers are likely to grow cash crops (e.g., Fafchamps (1992)). The starting point is that, because of high transport costs and low agricultural productivity, rural food markets are thin and isolated (e.g., Timmer (1986), Dercon (1995), Barrett (1997), Shively (1996)). Consequently, farmers are confronted with food prices that are volatile and highly correlated with their own agricultural output. Since basic staples constitute a large share of total consumption and have low income elasticity, farmers are adamant to protect themselves against food price risk. In most cases, this is optimally achieved by emphasizing food self-sufficiency. Wealthier farmers, however, spend proportionally less on food. By the same reasoning, they also prefer to allocate proportionally less of their land to food crops.

To show this formally, let the producer’s maximization problem be written:

$$Max_{L_i} \; EV(y, p) \tag{96}$$

subject to

$$y = \sum_{i=1}^{N} \pi_i L_i \quad , 0 \le L_i \le \bar{L} \quad \text{for all } i \quad \text{and} \quad \sum_{i=1}^{N} L_i = \bar{L} \tag{97}$$

where, as before, $V(y, p)$ is the indirect utility function, y is agricultural income, and p the vector of consumption prices. $\pi_i = p_i q_i$ is the revenue per acre of crop i, $\bar{L}$ is the producer’s endowment of the fixed factor of production, and L_i is the amount of the fixed factor allocated to crop i. Combining first order conditions for an interior optimum, one gets the usual series of equations $E[V_y \pi_i] = E[V_y \pi_j]$ for all i and j.[80]

Consider a first order expansion of the marginal utility of income around average income $\bar{y}$ and prices $\bar{p}$:

$$V_y \approx \bar{V}_y + \sum_{k=1}^{M} \bar{V}_{yp_k}(p_k - \bar{p}_k) + \bar{V}_{yy}(y - \bar{y}) \quad , \tag{98}$$

where M is the set of consumed goods and $\bar{V}_x$ stands for $V_x(\bar{y}, \bar{p})$. Let Ψ equal $-\frac{\bar{y}\bar{V}_{yy}}{\bar{V}_y}$, the

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[80] Corner solutions are ignored. The reason is that conditions leading to an increase (decrease) in level of an interior L_i are the same as those making it more (less) likely for a null L_i to become positive or for an interior L_i to become equal to $\bar{L}$. Thus, any conclusion reached for interior L_i’s quite naturally extends to non-interior ones.

coefficient of relative risk aversion with respect to income variability at $(\bar{y}, \bar{p})$ (e.g., Newbery and Stiglitz (1981)). Totally differentiating Roy's identity, we get:

$$V_y \approx \bar{V}_y[1 - \sum_{k=1}^{M} \bar{q}_k(\frac{\eta_k}{\bar{y}} - \frac{\Psi}{\bar{y}})(p_k - \bar{p}_k) - \frac{\Psi}{\bar{y}}(y - \bar{y})] \tag{99}$$

where $\bar{q}_i$ and η_i are respectively quantity consumed and income elasticity of consumption at $(\bar{y}, \bar{p})$. Multiplying by π_i and taking expectations, the above expression becomes:

$$E[V_y\pi_i] \approx \bar{V}_y\{E[\pi_i] - \sum_{k=1}^{M} s_k(\eta_k - \Psi)E[\pi_i(\frac{p_k}{\bar{p}_k} - 1)] - \Psi E[\pi_i(\frac{y}{\bar{y}} - 1)]\} \tag{100}$$

where s_k stands for the consumption share of good k at average prices and income $\bar{p}_k\bar{q}_k/\bar{y}$. In order to simplify the above expression, let the expected revenue per acre of one of the crops, say $E[\pi_n]$, serve as numeraire. Plugging equation (100) into first order condition $E[V_y(\pi_i - \pi_j)] = 0$, dividing by $\bar{V}_y$ and by numeraire $E[\pi_n]$, and defining m_i as $E[\pi_i]/E[\pi_n]$, the following equation is derived:

$$(m_i - m_j)(1 + \Psi) \tag{P}$$

$$+\sum_{k=1}^{M} CV_{p_k}(m_j\rho_{\pi_j p_k}CV_{\pi_j} - m_i\rho_{\pi_i p_k}CV_{\pi_i})s_k(\eta_k - \Psi) \tag{Q}$$

$$-\Psi\frac{E[(\pi_i - \pi_j)y]}{\bar{y}E[\pi_n]} \approx 0 \tag{X}$$

where CV stands for coefficient of variation and ρ for coefficient of correlation. This equation must hold for all interior i and j. It is dimension-free and therefore homogeneous of degree zero in all prices and revenues.

The final step is to obtain an explicit expression for crop portfolio choices. Let l_i stand for $L_i/\bar{L}$. The farm income per acre can then be written as $\sum_{k=1}^{N} l_k\pi_k$. Manipulating expression (X) in the above equation and multiplying through by $\sum_{k=1}^{N} l_k m_k$, a system of $N-1$ independent linear equations with N unknowns l_k is obtained. The system is identified by adding the constraint that crop shares sum to one.

When there are only two crops, say 0 and 1, the optimal crop portfolio can be solved explicitly as:

$$l^* \approx Min(1, Max(0, \frac{-(P + Q) + \Psi S}{(m - 1)(P + Q) - \Psi T})) \tag{101}$$

where l stands for l_1 and m for m_1. $E[\pi_0]$ serves as numeraire. T and S stand respectively for: $CV_{\pi_0}^2 + m^2CV_{\pi_1}^2 + (1 - m)^2 - 2m\rho_{\pi_0\pi_1}CV_{\pi_0}CV_{\pi_1}$, and $m\rho_{\pi_0\pi_1}CV_{\pi_0}\ CV_{\pi_1}$ - $CV_{\pi_0}^2 + m - 1$.

Except for an approximation error, the optimal crop portfolio has thus been expressed as a function only of parameters that have an intuitive content: expenditure shares, income elasticities, relative risk aversion, ratio of expected returns, coefficient of variation of prices and revenues, and the correlation between prices and revenues.

3.1 Effect of consumption preferences on crop choices

The relationship between crop choices and consumption preferences is now analyzed in detail when two crops are produced. Crop revenues are assumed independent of the price of non-produced consumption goods. In order to further simplify notation, write $CV_{p_i}(\rho_{\pi_0 p_i} CV_{\pi_0} - m\rho_{\pi_1 p_i} CV_{\pi_1})$ as A_i for $i = 0, 1$.

First, consider how crop portfolio l^* changes with consumption shares. Totally differentiating the first order condition, the sign of dl^*/ds_i is the same as the sign of $A_i(\eta_i - \Psi)$. Four cases are possible, depending on whether A_i is positive or negative and whether income elasticity η_i is larger or smaller than the coefficient of income relative risk aversion.

The sign of A_i depends on whether $cov(\pi_j , p_i)$ is greater or smaller than $cov(\pi_i , p_i)$. Generally the covariance between the price of one crop and the revenue of the other is smaller than the covariance between price and revenue of the same crop (see infra). Consequently, the usual situation is that:

$$\frac{dl_i}{ds_i} > (<)\ 0 \quad iff \quad \eta_i < (>)\ \Psi \quad .$$

Income relative risk aversion is often believed to lie between one and, say, four (e.g, Newbery and Stiglitz (1981), Binswanger (1980), Binswanger and Sillers (1983)). Suppose that crop *i* is a staple food and that the other crop is not consumed, i.e. is a cash crop. In that case, the income elasticity of crop *i* is unlikely to be greater than one. Therefore, in the most usual situation, and other things being equal, a risk averse farmer whose share of food in total expenditure is large will produce proportionally more food than a similarly risk averse farmer whose share of food in total expenditure is small. Only farmers with a low share of food in total expenditures *will devote a significant amount of resources to cash crop production.* The result is reversed when the coefficient of relative income risk aversion is smaller than the income elasticity of food, a condition satisfied for instance by risk neutral farmers for whom food is a normal good.

Next consider the effect that the income elasticity of demand has on crop portfolio. Using the same argument as above, it follows that:

$$\frac{dl_i}{d\eta_i} < (>)\ 0 \quad iff \quad cov(\pi_i , p_i) > (<)\ cov(\pi_j , p_i) \tag{102}$$

Thus when $cov(\pi_i , p_i) > cov(\pi_j , p_i)$, the producer reduces production of a crop for which his income elasticity is large. The reason is that when consumption prices and crop output are correlated positively, growing a particular crop serves as insurance against consumption price uncertainty. But high income elasticity leads to a high expected utility *gain* from price variability (e.g., Turnovsky, Shalit and Schmitz (1980)). Consequently, a producer with high income elasticity for a particular crop will find it in his interest to be *less* insured and therefore to grow less of that crop.

The effect of income risk aversion on crop portfolio can similarly be approximated. The sign of $d\, l^* / d\, \Psi$ is the same as the sign of:

$$- A_0 s_0 - A_1 s_1 + m - 1 - \frac{S - lT}{1 + l(m-1)}$$

which is the combination of two effects: a direct portfolio effect captured by $m - 1 - \dfrac{S - lT}{1 + l(m-1)} = \dfrac{cov(y , \pi_0 - \pi_1)}{\bar{y}E[\pi_0]}$; and a consumption effect captured by the $A_i s_i$ terms.

The sign of the consumption effect again reflects the fact that growing a crop whose revenue is positively correlated with consumption prices is a form of insurance. Consequently, more risk averse farmers will seek to insure themselves against consumption price risk by increasing the production of consumed crops, provided that the covariance condition is satisfied and that the direct portfolio effect is not too strong.

The balance between the direct portfolio effect and consumption effect in general depends on the model parameters. It is worth pointing out, however, that the consumption effect may lead to the "perverse" result that *a more risk averse person chooses to produce more of the risky crop.* Whether or not such a situation arises depends critically on the share of the risky crop in consumption and on the covariance between price and revenue from that crop: the larger the share and the larger the covariance, the more likely a more risk averse producer is to shift production toward the risky crop.

Finally the three comparative static experiments can be combined to look at the effect that a rise in land assets, wealth, or expected income has on crop portfolio. Because of the assumption of constant returns to scale, differences in farm size have no effect on expected yields. They only affect portfolio decisions via their incidence on consumption shares, demand elasticities, and risk aversion.

Consider the case of interest in which farmers grow a food and a cash crop, income relative risk aversion is constant, and changes in income elasticities are small and can be ignored. Letting subscript f stand for food, the effect of an increase in wealth or expected income has the same sign as $\frac{A_f s_f}{y}(\eta_f - 1)(\eta_f - \Psi)$.

What is the most likely sign of the above expression? As has already been argued, the covariance condition necessary for $A_f s_f$ to be positive is likely to hold for staple foods because of their low price elasticity. The income elasticity for staple food can be large for poor households, but it is likely to remain below unity; that is, richer households are likely to spend a smaller fraction of their income on staple food. Finally, poor rural households facing various sources of risk, but with little insurance mechanisms to rely on, are likely to be risk averse. Thus, the most likely relationship between wealth (i.e. farm size) and cash crop emphasis is *positive.* This is also the most commonly observed situation.

Possible - but unlikely - configurations of parameters exist in which small farmers are more cash crop oriented. One is when risk aversion is low: $\Psi < \eta_f < 1$, a condition unlikely to hold among Third World small farmers. Another is when the self-consumed good is a luxury: $1 < \eta_f < \Psi$. This may occur in special circumstances, for instance when farmers produce a cash crop as well as a "noble" cereal such as rice or wheat but consume partly a purchased, inferior cereal such as sorghum or millet. Then poor farmers may indeed choose to produce more cash crop in order to purchase the inferior cereal.[81] Other possible candidates as high-income-elasticity agricultural products are fruits and vegetables, meat, dairy, oilseeds, and spices, at least over some income range. Their share of total expenditures, however, is likely to remain small and the consumption effect on crop portfolio limited.

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[81] Situations where this may be the case are irrigated perimeters along the Niger, Gambia (e.g, Kargbo (1985)), or Senegal rivers (e.g., Morris and Newman (1989)). Whether reversals are actually observed deserves more research. In Matlon (1977)'s study of Northern Nigeria, small farmers produce proportionally more cash crop and less food than middle size farmers. Unfortunately, the evidence required to show that this unusual pattern could be explained by consumption risk alone is not available.

3.2 Market integration and food self-sufficiency

The main reason why food prices in poor rural areas are highly variable is because rural food markets are thin and isolated (e.g., Baulch (1997), Baulch (1997), Dercon (1995), Barrett and Dorosh (1996), Shively (1996), Timmer (1986), Minten (1995)). They are thin because of low agricultural productivity and, hence, low marketed surpluses; they are isolated because of poor infrastructure and high transportation costs. This process is compounded by the fact that the very thinness of markets induces rural households and communities to aim for self-sufficiency, thereby further reducing interaction with the rest of the world. Food price volatility is thus an essential ingredient to a vicious circle of rural poverty that runs from low productivity to low marketed surplus to thin markets to volatile food prices to no specialization in high value cash crops to low productivity. To illustrate how this essential process operates, we simulate the effect of changes in market environment on crop portfolio using the model developed above. We begin by specifying the stochastic market structure and then present simulation results.

3.3 Modelling correlation between prices, revenues and output

To simulate the effect of market integration on crop choices, we first need to specify the relationship between supply and demand. We assume a fixed market demand from the rest of the world, with a constant price elasticity and we ignore possible general equilibrium effects. Given these assumptions, we can express prices and revenues as functions of both the random production shocks and the underlying demand characteristics. Assume that Q, the aggregate market supply, and q, individual output, are imperfectly correlated. Let $\hat{p} = a\overline{Q}^{-\kappa}$ denote the price corresponding to the average quantity supplied $\overline{Q}$; it is *not* in general equal to the average price. Parameter κ is the inverse of the price elasticity of demand. Using Taylor expansions (e.g, Mood, Graybill and Boes (1974), p. 181), one gets:

$$E[p_i] = E[aQ^{-\kappa}] \approx \hat{p}(1 + \tfrac{1}{2}\kappa(\kappa + 1)CV_Q^2) \tag{102}$$

$$V[p_i] = V[aQ^{-\kappa}] \approx \hat{p}^2\kappa^2 CV_Q^2 \tag{102}$$

Mean and variance of revenue, and correlation between price and revenue, can similarly be approximated as:

$$E[\pi] = E[aQ^{-\kappa}q] \approx \hat{p}\overline{q}(1 + \tfrac{1}{2}\kappa(\kappa + 1)CV_Q^2 - \kappa\rho_{Qq}CV_Q CV_q) \tag{103}$$

$$V[\pi] \approx \hat{p}^2\overline{q}^2(CV_q^2 + \kappa^2 CV_Q^2 - 2\kappa\rho_{Qq}CV_Q CV_q) \tag{104}$$

$$\rho_{\pi p} \approx \frac{\hat{p}^2\overline{q}(\kappa^2 CV_Q^2 - \kappa\rho_{Qq}CV_Q CV_q)}{\sigma_\pi \sigma_p} \tag{105}$$

Examination of equation (105) indicates that, for most values of the demand elasticity and the correlation between individual output and aggregate supply, correlation between price and revenue is positive. Only when demand is very elastic and individual output very highly correlated with aggregate output does the correlation between price and revenue become negative. Those two conditions are unlikely to be met simultaneously, particularly in poor rural areas. Consequently, the covariance condition necessary for many results of the previous sub-section is met in most cases. Equation (100) combined with equations (104) to (105) forms the basis of the simulations presented below.

3.4 Simulation results

Having formalized the market structure, we are ready to simulate the integration of the producer into a larger market, either via trade liberalization (e.g. removal of restrictions to trade such as check points and road blocks), or by the integration of the village economy into a larger regional or national market (e.g. via better transportation facilities or an improved marketing system). Market integration confronts the producer with entirely new market demand schedules for his crops and affects average price, price elasticity, price variance, and the correlation between prices and revenues. For agricultural products, one expects the price elasticity of market demand to be higher in large integrated markets than in small isolated markets. The reason is that markets covering a lot of geographical and sectoral diversity offer more substitution possibilities. The variance of prices, on the other hand, is likely to decline with market integration. Indeed, the major cause of yield variability is weather, and in a large geographical market aggregate supply will blend local disturbances that are partly uncorrelated. Finally, correlation between individual weather conditions on separate farms is likely to decrease with the distance separating them. Consequently the correlation between individual and aggregate output is also likely to decrease with market integration, thereby reducing the price and revenue correlation.

Numerical simulations examine the effect of changes in (relative) output prices; variance of aggregate food output; correlation between revenue and price; elasticities of aggregate demand; and correlations between crop revenues. Parameters used for the simulations are chosen to represent a typical Third World farming household (e.g., Fafchamps (1985), Fafchamps (1986), Matlon (1977), Binswanger (1980)): high variance of individual as well as aggregate output (coefficient of variation = 0.6), high correlation between individual and aggregate output (0.7), and low price elasticity of demand (0.5).

Households have the choice between growing a food crop (good 0) and a non-consumed cash crop (good 1). For simplicity, cash crop revenue is assumed independent from food price. Three hypothetical households are considered: the first does not consume any of its production and consumes food produced (or industrially processed) elsewhere; the second spends a moderate share (30%) of its income on locally produced food; and the third allocates a major share (80%) of its income to self-produced food. All households are assumed moderately risk averse.

The first household represents a fully commercialized farmer. The second is partially commercialized but not entirely reliant on the market for its food consumption. The third is a household that hardly grows any cash crop at the initial parameter values, is essentially self-sufficient in food, and sells any food surplus on the market in order to satisfy minimal non food needs. Given their consumption pattern, farmer 1 is likely to be richer and larger, and farmer 3 to be poorer and smaller. The simulations may also be thought of as contrasting crop portfolio behaviors predicted by univariate (household 1) and multivariate (household 2 and 3) expected utility models.

Results show that a change in the cash crop's average price has the expected supply response effect. There is a difference between the three households, however, in that poor households are less prone to produce the cash crop to start with. Therefore, richer households may respond to a price increase by allocating significantly more resources to cash crop production while poorer households remain entirely concentrated on the food crop. In other words, larger farms have a higher elasticity of cash crop supply response.

Higher food prices induce poor producers to revert to self-subsistence much faster than do fully commercialized farmers. Smaller farms thus have a higher price elasticity of food production.

An increase in food price variance, keeping average price constant, has a non-monotonic effect on output (Figure IV.1). All three households initially increase food production as a result of a small increase in variance of food prices, but their reaction to further increases in that variance is different. As food prices continue becoming more volatile, market oriented households finally revert to cash crop production because higher variance increases expected revenue. The volatility of food prices increasingly hurts poor households, however, and induces them to maintain a high level of food self-sufficiency. Less correlation between individual and aggregate food output has a small positive effect on cash crop production among commercialized farmers, but only a small and ambiguous impact on poor farmers.

Changes in the price elasticity of market demand faced by producers affects crop choices in a nonlinear way via their impact on expected revenues and the covariance matrix between prices and revenues. Results show that a large increase in demand elasticity for the cash crop (Figure IV.2) does not eliminate the difference in crop emphasis between the three households. Since, from the point of view of the producer, a fixed price is similar to an infinitely elastic demand, this suggests that fixing the price of a cash crop need not be sufficient to induce small farmers to grow it. On the other hand, fixing the price of the *food* crop (Figure IV.3) is a very effective way of dramatically reducing differences between farms as well as of increasing the cash crop production of small farmers. Finally, a decrease in correlation between crop revenues has no impact on crop choices in the absence of consumption effects (household 1), but encourages slightly more emphasis on cash crops when consumption effects are important (Figure IV.4).

To summarize, these results suggest that market integration progressively diminishes the need for food self-sufficiency. As better roads and transportation equalize price movements across a larger regional or international market, food prices ought to become increasingly dissociated from local supply and demand conditions. All the effects of market integration - a lower variance in food prices, less covariance between individual output and aggregate supply, a more elastic demand because of substitution and international trade possibilities - reduce an individual's rationale for food self-sufficiency.

3.5 Policy Implications

In many developing countries, cash crops are by definition already integrated in international markets while food markets remain local in nature. Food market integration would thus reduce price variance and the correlation between individual and aggregate output. It is also likely to increase the market price elasticity of food demand and to decrease the correlation between crop revenues. Results presented in the previous sub-section suggest that these effects combine to decrease small farmers' need to rely on their own food production. Promoting food market integration by investing in roads and transportation, and removing institutions or policies impeding domestic trade, are therefore essential in order to allow crop specialization. Agricultural resources freed from staple food production may possibly be used more efficiently producing cash crops. Less concern for food self-sufficiency would also increase farmers' supply response to cash crop price incentives.

The analysis presented above also suggests that a similar outcome may be achieved or strengthened by selling food at controlled prices in villages. The Indian government, for instance, has used state-owned retail outlets to pursue a cheap food policy in rural areas. It would be worthwhile reviewing the effect of that policy in light of the ideas presented here. To summarize, *food* market integration via reduced trade restrictions, better roads and transportation, and/or government food shops can be a powerful tool to boost cash crop production and to increase responsiveness of small farmers to price incentives. For many Third World countries with debt service problems, this may be an effective way of generating badly needed foreign exchange.

The analysis presented here also has a number of policy implications regarding technological change. The effect of successful technological innovations through farmers' incomes has already been explored in detail in Section 2, where it was concluded that producers with higher incomes are likely to put more emphasis on cash crop production. Hence, other things equal, technological change should boost cash crop production by raising incomes.

Technological change in agriculture, however, is often crop-specific. The model presented here throws new light on the issue of crop bias in agricultural research. Improving cash crop productivity, as many African countries have done (e.g., Eicher and Baker (1982)), will fail to reach the many farmers who, for food security reasons, are unable to allocate a significant amount of resources to cash crop production. Besides, it would favor only better-off farmers who are in a position to grow cash crops.

At the same time, however, improving food crop productivity has limited potential for agricultural growth if food markets are not better integrated. Indeed, as long as food markets remain isolated by government policies, difficult transportation, and high marketing costs, households will prefer to allocate the freed resources to cash crop production as soon as food security is satisfied. This may lead to the paradoxical situation in which improved food production technology ends up favoring cash crop production.

The latter problem has several consequences. First, limiting technological improvements to cash crops is counterproductive. Even if a country's only objective is to increase cash crop production, a certain amount of resource-saving innovation is required to alleviate food security concerns of poor households with loosely integrated food markets. Consequently, even in countries that rely heavily on cash crops for foreign exchange generation, and which typically seek to maximize cash crop production, productivity increases should be sought in both cash and food crop production.

Second, at least in some countries, food crops also have the potential to become cash crops given the proper market environment and infrastructure (e.g. Kenya or Zimbabwe). The model presented here suggests that combining food market integration with increased food crop productivity has a good chance of success. Indeed, it would directly address farmers' food security concerns, and at the same time promote a global increase in agricultural output. Whether such an option is feasible depends in part on the national and international market for the specific types of food that a country or region is able to produce. For instance, semi-arid regions that can only produce coarse cereals with low income elasticities probably must wait for the emergence of a sufficiently large local market for animal feed.

Section 4. Precautionary Saving and Investment Constraints

It has often been claimed that risk averse producers unable to insure themselves against income shocks tend to shy away from risky activities (e.g., Arrow (1971), Pratt (1964), Sandmo (1971)). This idea has been used to explain why poor producers find it difficult to invest in production enhancing technologies. However, as argued earlier, this apparently simple and straightforward explanation evaporates once subjected to intense scrutiny -- at least in the way it is customarily described and modeled. The main reason is that it ignores the fact that the poor have developed ways of dealing with risk. In the presence of complete or incomplete insurance, aversion toward risk is not the appropriate concept.

An alternative explanation for the poor's difficulty to invest has been the existence of credit constraints. This approach similarly ignores the time dimension: when faced with a profitable investment opportunity, the poor may be unable to invest today but they can in principle save to undertake the investment at a later date. Poverty, *per se*, thus fails to explain why investment does not take place in the long run. In this section we propose an alternative approach that combines the risk aversion and the credit constraint ideas into a single dynamic model. We investigate the extent to which poor households are discouraged from making highly profitable but non-divisible investments and we show that poverty, credit, saving, and risk are closely related.

The intuition behind our approach can be summarized as follows. Poor farm households have at least two motives for saving: to insure against income shortfalls, and to self-finance profitable investments when credit is not available. If returns to savings are low, they may find it difficult to accumulate enough wealth to finance a large non-divisible investment, even if it is highly profitable. They remain trapped in poverty (e.g, Lewis (1954), Nurkse (1953)). Investment irreversibility may also serve as an additional deterrent to investment. A reversible investment can be turned into liquidities should the household face an external shock beyond what can be handled with other accumulated wealth. An irreversible investment, on the other hand, detracts permanently from the household's liquid wealth and thus impinges on its ability to self-insure. A household with a precautionary motive for holding wealth may thus treat irreversible and reversible investments differently. In particular, the wealth threshold at which it is willing to make a reversible investment may be below that at which it makes an irreversible investment. To illustrate these concepts, we construct and simulate a stochastic dynamic programming model of savings and investment. The model shows the role that non-divisibility and irreversibility plays in investment decisions.

It has long been recognized that poor farmers in the Third World find it hard to finance large, lumpy investments (e.g., McKinnon (1973)). Credit constraints are commonly regarded as the major explanation for this state of affairs and much emphasis has been put in the literature on the role that credit constraints play in farm size distribution and investment patterns (e.g., Carter (1988), Eswaran and Kotwal (1986), Feder (1985), Iqbal (1986)). Credit constraints may result from interest rate restrictions (e.g., Gonzalez-Vega (1984), McKinnon (1973), Shaw (1973)), from asymmetric information (e.g., Stiglitz and Weiss (1981)), or from enforcement considerations (e.g., Bell (1988), Pender (1996)). In addition, in a risky environment farmers may choose to avoid credit if the penalties for default are sufficiently severe. Regardless of the reason, farmers in developing countries must thus often self-finance a large share of the investments they make. Trying to determine what impact this has on their ability to make a highly profitable but non-divisible and irreversible investment is the object of this section.

A key question is why poor farmers who lack access or willingness to use credit do not choose to save in order to self-finance highly profitable investments. One possible explanation is that they find it hard to save. Often contributing to the difficulty are government interest rate restrictions and other policies that keep the returns to savings low (e.g., McKinnon (1973)). Such policies were in place in India during the 1970's and 1980's, the period of the present study (e.g., Pender (1992)). Being constantly faced with life-threatening situations for which poor farmers must liquidate their meager assets, the argument goes, they can never accumulate enough to finance a large investment. We investigate this possibility directly by examining the saving and investment behavior predicted by models of precautionary saving.

A second possible explanation is that the irreversibility of well construction operates as a disincentive to invest. As Epstein (1978) stressed early on, flexibility, that is, the capacity to revise certain decisions assumes an important role in a multi-period setting. Fafchamps (1993), for instance, estimates a three-period structural model of labor allocation decision in semi-arid farming and demonstrates that flexibility differently affects farmers' decision to plant and weed. Dixit (1989) and Dixit and Pindyck (1994) have shown that it may be optimal for an investor faced with a (partly or totally) irreversible investment to wait until more information is available on the investment's profitability. By investing now, the investor indeed loses the option to collect more information and make a better decision later.

The situation we are interested in is different in that little or no new information is gained over time about the profitability of the investment. Investment irreversibility may nevertheless affect the investor's decision if the investor has a precautionary motive for saving. By waiting, the agent is better able to use liquid wealth to cope with income shortfalls. Tying all her money into an illiquid asset may generate an unbearable risk. The trade-off between a higher return on wealth and better consumption smoothing may thus generate a liquidity premium, that is, a level of precautionary savings deemed comfortable enough for the investment to take place. The liquidity premium might, however, be zero if the investment itself reduces risk, as is typically the case for irrigation.

Hints that irreversibility matters can be found in Rosenzweig and Wolpin (1993). Using household survey data from semi-arid India, the authors show that poor farmers are less likely to invest in irrigation equipment than in bullocks despite the fact that the return on the former is higher than that on the latter. The reason is, they argue, that bullocks can be sold when the need arises while pumps cannot. We revisit this issue and attempt to quantify the effect that irreversibility and credit constraints have on farmers' willingness to undertake a large, non-divisible investment.

4.1 Investment and precautionary saving

We begin by developing a model of self-financed, non-divisible investment. The model combines a continuous decision -- how much to save -- with a discrete choice -- whether to invest in a well or not. The possible effect of irreversibility is explicitly taken into account. We consider an agent who faces two possible i.i.d. income streams with probability distributions $F(y;\tau_0)$ and $F(y;\tau_1)$. By building a well at cost k, the agent can exchange an income stream $F(y;\tau_0)$ against the income stream $F(y;\tau_1)$. Parameter vectors τ_0 and τ_1 thus characterize the shape of the income distribution without and with a well, respectively. Income is restricted to the positive orthant, i.e. $y \in [0, \infty)$. We consider two cases, one in which the agent cannot recoup investment cost k and revert to $F(y;\tau_0)$ -- the irreversible case -- and one in which she can -- the reversible case. We begin with the irreversible case.

4.2 A model of irreversible non-divisible investment

Let X_t stand for the agent's cash on hand at time t, i.e.,

$$X_t = W_t + y_t(W_t)$$

where W_t is the agent's accumulated wealth at the beginning of year t and y_t is her realized net income from all sources at the end of year t, which is a function of liquid wealth at the beginning of the period. After the investment, the optimization problem facing the agent is summarized by the following Belman equation:

$$V_1(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - W_{t+1}) + \beta \int_0^\infty V_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1};\tau_1) \qquad (1)$$

Instantaneous utility $U(.)$ is continuous and concave and exhibits decreasing absolute risk aversion: the agent thus has a precautionary motive for saving (e.g., Kimball (1990)).

We further assume that $U(c) > -\infty$ for all $c \geq 0$ -- but is $-\infty$ or not defined for $c < 0$: the agent cannot have negative consumption. This implies that, as Zeldes (1989) and Carroll (1992) have shown, the agent optimally decides never to borrow beyond the annuity value of her minimum possible income. We further assume that, under both income streams, the minimum possible income is 0. Then, along the optimal path the agent never is a net borrower: if creditors insist on being paid under any circumstance, then an agent with a minimum income of zero will not be able to become a net debtor and net borrowing can not be used to smooth consumption. An alternative interpretation is to postulate that there is a penalty for breach of contract and that the penalty is so severe that the agent chooses not to incur debt. (The same argument applies to strictly enforceable contingent contracts -- Zame (1993).) Whether the agent is refused credit because she cannot repay in all possible states of the world, or fears the possible consequences of default, the result is the same. Of course, if default is allowed, credit can be used to provide insurance (e.g., Eaton and Gersovitz (1981), Grossman and Van Huyck (1988), Kletzer (1984)).

Let δ be the agent's rate of time preference, i.e., $\frac{1}{1+\delta} \equiv \beta$. If we further assume that δ is greater than the return on liquid wealth, the agent is a natural dissaver: she saves for the sole purpose of smoothing consumption (e.g., Deaton (1991), Kimball (1990)). As argued in Deaton (1990), Deaton (1992), Deaton (1992)), countless poor consumers, particularly in Third World countries, find themselves exactly in this predicament. Now consider the agent's decision before the investment has taken place. Formally, the agent computes her expected utility under two alternative scenarios: invest now, or wait until later. In case she invests now, her expected utility is:

$$V_0^1(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - k - W_{t+1}) + \beta \int_0^\infty V_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1}; \tau_1) \tag{106}$$

In case she chooses to wait, her expected utility is:

$$V_0^0(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - W_{t+1}) + \beta \int_0^\infty V_0(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1}; \tau_0) \tag{107}$$

The agent chooses to invest if $V_0^1(X_t) > V_0^0(X_t)$. The value function $V_0(X)$ corresponding to the no-investment situation can thus be found by solving the following Belman equation:

$$V_0(X_t) = Max\{V_0^0(X_t),\ V_0^1(X_t)\} \tag{108}$$

It can be shown that the option to invest in the future is valuable even though, unlike in Dixit and Pindyck (1994), no new information is gained about the investment's profitability:

Proposition IV.1:

(1) If the return to the investment is such that there exists a level of wealth at which the agent would want to invest, then the option to invest raises the agent's *ex ante* utility

(2) An agent given the option to wait may defer investment compared to an agent who must invest now or never

In Proposition IV.1 we assume that a sufficiently wealthy individual would want to invest. But, depending on the parameters of the model, it may be optimal for her never to invest. If, for instance, $F(y; \tau_0)$ stochastically dominate $F(y; \tau_1)$, then investing is not optimal since it would reduce the agent's expected utility for any initial level of cash on hand.

The converse is not true, however: even if $F(y\,;\tau_1)$ stochastically dominate $F(y\,;\tau_0)$, investment will not take place if the agent has insufficient wealth, i.e., if $X_t < k$. Sufficient (but not necessary) conditions for investment to be a valuable option are, first, that the investment is profitable, that is, yields a positive expected return:

$$\int_0^{\infty} y\ dF(y\,;\tau_1) - \int_0^{\infty} dF(y\,;\tau_1) > r\,k \tag{A1}$$

where r is the expected return on liquid wealth W_t. The second condition is that the agent is asymptotically risk neutral, i.e.:

$$\lim_{c \to \infty} \frac{c\,U''(c)}{U'(c)} = 0 \tag{A2}$$

If these two conditions are satisfied, then the existence of a level of cash on hand is guaranteed above which the agent invests and one (possibly the same) below which she refrains from investing:

Proposition IV.2:

(1) Given (A1-2), there exist at least one x^* such that $V_0^0(x^*) = V_1(x^*-k)$.

(2) If x^* is unique, for all $x > x^*$, the agent invest, and for all $x < x^*$, the agent does not invest.

(3) If x^* is not unique, let $\overline{x}^*$ and $\underline{x}^*$ be the largest and smallest x^*, respectively. Then, for all $x > \overline{x}^*$, the agent invest, and for all $x < \underline{x}^*$, the agent does not invest

In the remainder of this section, we focus our attention to the simple case in which there is a level of wealth at which investing is optimal. Let X^* be the minimum level of cash in hand at which the investment takes place -- that is, such that $V_0^0(X^*) = V_1(X^* - k)$. We then define the *liquidity premium* P as the amount of liquid wealth that the agent wishes to hold immediately after the investment:

$$P \equiv arg \underset{W_{t+1}}{Max}\, U(x^* - k - W_{t+1}) + \beta \int_0^{\infty} V_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1};\tau_1)$$

The liquidity premium acts as a deterrent to investment because the agent must accumulate not only the cost of the investment itself but also the amount of liquid wealth he/she wishes to hold as precautionary saving.

4.3 Precautionary saving and reversible investment

The cost of irreversibility can be found by considering the reversible case. Formally, the latter case can be seen as an extension of the irreversible case. In each period, the agent can be in one of two states: with or without the investment. Each of these states has its own value function. The value functions, in turn, reflect the fact that, before deciding on consumption, the agent may invest and pay k, or liquidate the investment and receive k. Intermediate cases in which divestment is possible but at a cost can be analyzed in a similar manner. We thus get a system of two Bellman equations:

$$\overline{V}_0(X_t) = Max\{\overline{V}_0^0(X_t),\ \overline{V}_0^1(X_t)\} \tag{109}$$

$$\overline{V}_1(X_t) = Max\{\overline{V}_1^1(X_t),\ \overline{V}_1^0(X_t)\} \tag{110}$$

where:

$$\overline{V}_0^0(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - W_{t+1}) + \beta \int_0^{\infty} \overline{V}_0(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1};\tau_0) \tag{111}$$

$$\overline{V}_0^1(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - k - W_{t+1}) + \beta\int_0^{\infty} \overline{V}_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1}; \tau_1) \quad (112)$$

$$\overline{V}_1^1(X_t) = \underset{W_{t+1}}{Max}\, U(X_t - W_{t+1}) + \beta\int_0^{\infty} \overline{V}_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1}; \tau_1) \quad (113)$$

$$\overline{V}_1^0(X_t) = \underset{W_{t+1}}{Max}\, U(X_t + k - W_{t+1}) + \beta\int_0^{\infty} \overline{V}_0(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1}; \tau_0) \quad (114)$$

As before, $\overline{V}_0^1(X_t) = \overline{V}_1(X_t - k)$ and $\overline{V}_1^0(X_t) = \overline{V}_0(X_t + k)$. This system can be solved simultaneously by backward induction. The liquidity premium for a reversible investment can similarly be defined as:

$$\overline{P} \equiv arg\, \underset{W_{t+1}}{Max}\, U(x^* - k - W_{t+1}) + \beta\int_0^{\infty} \overline{V}_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1}; \tau_1) \quad (11)$$

$P - \overline{P}$ represents the option cost of irreversibility. It is clear that, if the return on the non-divisible investment is certain and investors face credit constraints, the cost of irreversibility $P - \overline{P} \geq 0$. When the return to investment is variable, however, $\overline{P}$ need not be 0. To see why, note that when the investment is reversible, $\overline{P} + k$ is the level of precautionary saving. As Dreze and Modigliani (1972) and Kimball (1990) have shown, this level is an increasing function of the variance of income when absolute risk aversion is decreasing. Thus, the higher the variance of income after investment, the higher $\overline{P}$. For a sufficiently high variance of the post investment income process, therefore, $\overline{P} > 0$. A contrario, if undertaking the investment reduces the variance of income and the investor is credit constrained, then $\overline{P}$ may be zero. In that case, P alone constitutes a good indicator of the cost of irreversibility. Finally, $\overline{P}$ cannot exceed P: irreversibility can only raise the liquidity premium in the presence of credit constraints and a precautionary motive for saving. If $P = 0$, then $\overline{P} = 0$ as well.

Reversibility does not imply that the savings behavior of the agent is unaffected by the presence of a non-divisible, high return investment. As Pender (1992) has shown in the certainty case, in the presence of credit constraint the agent's willingness to save increases in the vicinity of the threshold level of wealth k -- even if it means momentarily accumulating wealth at a rate of return inferior to δ. The reason is that the agent anticipates the benefits from higher returns and strives to reap them. Pender (1992) shows that a low return on saving may have a perverse disincentive effect on investment because it makes it difficult for a credit constrained agent to accumulate enough to undertake the investment (e.g., McKinnon (1973)). The presence of a liquidity premium reinforces this argument: not only do agents have to accumulate enough to invest, they must also build up a sufficient buffer stock of liquid wealth. A low return on liquid wealth thus has a disincentive effect of on an agents' willingness to accumulate and invest that is compounded by the presence of a liquidity premium.

4.4 Poverty, shocks, and investment

Using the ICRISAT data from India, Fafchamps and Pender (1997) econometrically estimate a model of irreversible investment in wells. Investments in individual wells for irrigation offer a perfect opportunity to study the effect of non-divisibility and irreversibility on investment behavior. The ICRISAT data have been widely used to study issues relative to consumption smoothing and wealth accumulation patterns (e.g., Morduch (1990), Morduch (1991), Pender (1996), Rosenzweig (1988), Rosenzweig (1988), Rosenzweig and Wolpin (1993), Townsend (1994)). They are particularly well suited for our purpose because most of the assumptions made by our model are satisfied: villagers are known to be risk averse (e.g., Binswanger (1980)) and impatient (e.g., Pender (1996)); they are poor and face a lot of risk (e.g., Walker and Ryan (1990)); they are unable to fully insure through mutual insurance and credit arrangements (e.g., Morduch (1991), Townsend (1994)); they are unable to fully finance the cost of well construction through credit (e.g., Pender (1992)); and they buy and sell assets to smooth consumption (e.g., Lim and Townsend (1994), Rosenzweig and Wolpin (1993)).

Estimation results by Fafchamps and Pender (1997) yield estimates of an intertemporal discount rate of 18% and estimates of relative risk aversion reverting around 1.8-3.1, somewhat high but not altogether implausible given the low income levels in the area (e.g, Walker and Ryan (1990)). The model fits observed behavior fairly well, given the panel nature of the data. Using an Euler equation approach and assuming a constant relative risk aversion coefficient as we do here, Morduch (1990) estimated the coefficient of relative risk aversion in the same village to be 1.39. Discount rate estimates are all well above 5% and vary between 17% to 29%. These values are lower but of the same order of magnitude as the median discount rates measured by Pender (1996) using experimental games in two of the ICRISAT villages. Discount rates are not a direct measure of the pure rate of time preference δ since they are affected by consumption smoothing motives as well. But if we account for seasonal effects and income shocks, the existence of high discount rates in semi-arid India (median values between 50% and 60% in most experiments) is consistent with a rate of time preference as high as estimated here.

4.5 Credit constraints and poverty trap

Armed with estimates of risk aversion and discount rate, we are now in a position to ascertain whether the precautionary motive for saving plays a significant role in surveyed households' reluctance or inability to invest in well construction. Using the parameters estimated by Fafchamps and Pender (1997), we simulated the threshold cash-on-hand and liquidity premium at which a poor household invests in a large irreversible investment such as an irrigation well. The threshold cash-on-hand is found iteratively as the X^* at which the following equation is satisfied:

$$\underset{W_{t+1}}{Max}\, U(X^* - k - W_{t+1}) + \beta\int_0^\infty V_1(W_{t+1} + \tilde{y}_{t+1}(W_{t+1}))dF(\tilde{y}_{t+1};\tau_1) = \tag{115}$$

$$\underset{W'_{t+1}}{Max}\, U(X^* - W'_{t+1}) + \beta\int_0^\infty V_0(W'_{t+1} + \tilde{y}_{t+1}(W'_{t+1}))dF(\tilde{y}_{t+1};\tau_0)$$

The liquidity premium is simply W_{t+1} at the solution of equation (115).

Results show that for a highly profitable investment such as an irrigation well in the ICRISAT villages, the liquidity premium is positive but small: once they reach the required threshold cash on hand, households are predicted to invest almost all their wealth in digging the well. For most households, irreversibility constitutes a relatively minor impediment to investment. This is not the case, however, for less profitable investments. Simulation results then show that some households may never invest in the well. For those who invest, the liquidity premium can amounts to a large proportion of the investment cost and the threshold cash in hand goes up by a significant percentage. In this case, irreversibility clearly deters investment, the reason being that poor investors do not want to freeze all their liquid wealth in a fixed asset.

For sufficiently poor households, the combination of the indivisible nature of the investment and the desire to retain some liquid wealth after the investment has been undertaken makes it extremely difficult to accumulate the threshold wealth necessary for investment. In simulations based on the parameters estimated by Fafchamps and Pender (1997), the threshold cash on hand at which households without well would consider investing is equivalent to more than three times their average pre-investment income, and is over twice their average cash on hand after harvest. Many households thus fail to undertake the investment in irrigation simply because they are unable to accumulate enough wealth to cover the investment cost. To verify this possibility, the income and saving patterns of a household with the average characteristics of Fafchamps and Pender (1997)'s sample were simulated. One hundred simulations were conducted, each of them fifty years long. Results indicated that in none of these one hundred simulations does the household accumulate enough to invest in the well. Households appear trapped -- in a probabilistic sense -- in poverty: because their income is low, they are too concerned about their immediate survival to accumulate much, they never manage to have enough to undertake an indivisible but highly profitable investments, and they remain poor.

Simulation results nevertheless indicate that poor households attempt to save for the well. The liquid savings for households facing the option to invest in the well were simulated and compared with those of hypothetical households without that option. On average, households with the option to construct a well save 40% more than identical households without it. These results are consistent with theoretical propositions derived by Pender (1992): the poor attempt to save for the well, but accumulating enough is simply too hard for most of them.

To test whether credit can help households out of poverty, the simulations were redone assuming that the household can borrow part of the value of the investment at a low interest rate. Debt repayment is assumed forgiven in bad years.[82] Results show that in almost all the simulations, investment takes place. The waiting time to investment is long, however: 19 years on average for investing households. The reason is that, with borrowing, the threshold cash on hand is less half of what it is without borrowing. This puts the investment within the range of what households can afford with moderate savings after a good cropping season.

To check whether subsidizing credit plays an important role, the simulations were redone assuming that borrowed funds carry a higher (real) interest rate. Results indicate a reduction in investment, but the rate charged on borrowed funds must be raised substantially before all investment disappears. From this we conclude that what matters is not so much the cost of credit but rather its availability. To successfully promote well construction, credit must bring investment within the reach of poor households. These results are in line with the success of programs such as the Grameen Bank (e.g., Pitt and Khandker (1996)).

McKinnon (1973) Pender (1992) argue that higher returns on liquid wealth can make investment possible by encouraging household to save. To investigate this possibility, the model is simulated with higher returns to liquid wealth, as could be achieved, for instance by a deregulation of interest rates on savings account. Simulation results confirm McKinnon and Pender's theoretical intuitions but they also indicate that, in this particular case, a sizeable increase in returns to liquid wealth is required for a noticeable rise in investment materializes.

[82] This assumption is essential, otherwise agents optimally decide not to incur debt (see supra).

4.6 Poverty, investment, and non-divisibility

In this section we investigated whether poor farmers are discouraged from making highly profitable investments which non-divisible and irreversible. We constructed a model of irreversible investment by an agent with a precautionary motive for saving. Simulations conducted with estimated parameters suggest that many poor farmers may find themselves trapped in poverty due to their inability to accumulate enough wealth to self-finance the construction of an irrigation well. Risk aversion *per se* does not explain the reluctance to invest: farm incomes with a well stochastically dominate incomes without. Irreversibility constitutes a small additional deterrent to investment.

These results demonstrate empirically the magnitude of the inefficiency and inequity caused by poor households' inability to finance profitable but non-divisible investments. An investment yielding a high real rate of return was forgone by most households who were, in effect, forced to accept a lower return on divisible liquid wealth. In the context of financial repression common in many developing countries, such outcome is consistent with concerns raised by McKinnon (1973), Shaw (1973) and others in the 1970's. They also suggest the importance for poor farmers of having access to remunerative savings opportunities (e.g., McKinnon (1973), Pender (1992)).

This section presents the advantage of integrating the theory of precautionary saving with that of credit constraints and irreversible investment under risk. A similar approach can be applied to other investments in which non-divisibility may serve to deter investment by poor households, e.g., human capital accumulation, or firm creation and expansion. Irreversibility is a feature common to many economic decisions. Investment in schooling, human fertility, and the construction of a production unit, for instance, are all situations in which decisions cannot be reversed. Partial irreversibility is even more widespread as many decisions can only be reversed at a cost: e.g., migration, purchase of durables, purchase of equipment. This section has shown that agents with a precautionary motive may refrain from incurring any of these irreversible investments.

Section 5. Risk Sharing and Risk Taking

The poor are not only less able to take risk because they do not have the financial and human capital required to invest; they are also less willing to bear additional risk. Mutual insurance with other villagers may reduce some of these inhibitions and encourage risk taking. The sharing of risk, however, also dilutes incentives for risk taking, especially if the egalitarian social norms on which solidarity is founded force the redistribution of success as well as failure. Allowing less egalitarian forms of risk sharing, such as patronage, eliminate this problem but creates other difficulties, the most important one being the tendency for the poor to further impoverish themselves. The net effect of mutual insurance on risk taking is thus ambiguous. This section delves into these issues more in detail.

5.1 Norms of risk sharing in rural communities

It has been argued that norms of risk sharing that are prevalent in poor rural communities operate as wealth redistribution mechanisms and, as such, discourage the rural poor from saving and investing. In a couple of recent papers, Platteau and Hayami (1996) and Platteau (1996) revisit these issues and go as far as proposing a division of pre-industrial agrarian societies into two groups. The authors argue that Asian-type societies are those in which norms of risk sharing do not impose an excessive tax on returns to effort, individual accumulation is allowed and encouraged, and development takes place. In contrast, African-type societies have norms of risk sharing that impose an excessive tax on returns to effort, thereby discouraging individual accumulation and holding back development.[83] To explain why this might be the case, Platteau and Hayami (1996) bring to the fore geographical and technological factors that have shaped rural societies. Platteau (1996) adopts a Boserup (1965) style argument and notes that population density determines techniques of production such as irrigation. By reducing crop risk, Platteau argues, irrigation means that returns to effort are more easily identifiable. Consequently, the cultural representations of societies with irrigation recognize more clearly a link between effort and outcomes.

Although there is probably an element of truth in the idea that risk sharing discourages accumulation, the claim that this process might account for the relative performance of entire continents is, I believe, unreasonable. The truth is more complex and requires that we disentangle the sharing of income and consumption risk from the redistribution of wealth. To address these issues, we first discuss the circumstantial evidence regarding individualism and accumulation in poor societies in general and in Africa in particular. Next, we revisit some of the conceptual underpinnings of the relationship between risk sharing, risk taking, and investment. We continue with a detailed discussion of asymmetric forms of risk sharing, also called patronage, and their relationship with investment and development.

5.2 Circumstantial evidence on individualism

Let us begin by saying that there is little doubt that most people in poor rural societies anywhere, including Sub-Saharan Africa, recognize that individual effort raises income. If they did not, it is hard to see why they would work at all. Fafchamps and Minten (1998) indeed show that, if anything, poor traders are more individualistic and less inclined to share risk with others than large traders. The claim that the rural poor in certain parts of the world do not work hard because they do not see a relationship between effort and income is too far fetched -- at least stated in these general terms.

Second, it is difficult to believe that people's desire to accumulate wealth and power is less strong in some parts of the world than in other parts of the world because of social norms emphasizing redistribution. There is indeed plenty of circumstantial evidence that poor rural areas are not immune to individualism and opportunism (e.g., Popkin (1979), Poewe (1989)). The history of Africa, just like any other part of the world, provides ample -- and often unsavory -- evidence of accumulation and greed, including a long history of slavery (e.g., Watts (1983), Bayart (1989), Hopkins (1973), Shillington (1989)). In areas with a low population density and shifting cultivation is practiced, individual land property rights are costly to enforce (e.g., Binswanger and McIntire (1987)).[84] Accumulation then historically takes a different form, i.e., the control over 'bodies' through slavery, labor bonding, and polygamy. In contrast, where labor is plentiful power comes from the accumulation of other means of production such as land and cash. The fact that accumulation in low population density/high enforcement costs areas takes a different form from other areas may have been misinterpreted as a sign that accumulation is less important. This is probably erroneous, although it is important to recognize that the accumulation of control over bodies is not achieved by the same

[83] Some of the same arguments have already been used to explain the relative performance in South-East Asian countries. See, for instance, the largely inconclusive controversy between Scott (1976) and Popkin (1979).

[84] Latin America is an exception to this rule: historically, land has been plentiful but the state has protected the property rights of large landowners, thereby creating a class of landless peasants in spite of land abundance.

means as the accumulation of land and financial wealth. This may have implications regarding investment and development that we discuss below.

5.3 Risk sharing, investment, and saving

Platteau and Hayami (1996) argue that risk sharing decreases investment because it taxes success. This is forgetting that risk sharing also reduces the cost of failure. As we have discussed earlier, poor producers might be deterred from investing in new technologies and market opportunities because they are concerned about downside risk, that is, the possibility that they might not survive a bad shock. By protecting producers from the worst consequences of shocks and ensuring their survival, risk sharing ought to favor investment and risk taking for the same reasons that formal insurance, venture capital, derivative markets, and portfolio diversification favor investment in developed economies. In other words, we should expect the insurance dimension of risk sharing to favor investment and risk taking, not discourage them. Even if risk sharing mechanisms tax success, their net effect on development could thus be positive.

Risk sharing might, however, reduce the need for precautionary saving and thus lower aggregate saving (see Chapter II). Although this is probably true, one should keep in mind that precautionary balances must be kept in liquid form to serve their purpose. This implies that what the rural poor save to deal with risk is in general kept in grain stocks, small livestock, cash, jewelry, and deposit accounts (see Chapter II). The need for liquidity means that the poor will be willing to save in instruments that have a low or even negative return, such as grain stocks carried over from year to year, and cash in inflationary economies. Such forms of investment are hardly efficient from society's perspective, so that reducing precautionary saving might improve allocative efficiency.

Furthermore, as we have argued earlier, precautionary balances are unlikely to finance the purchase of large, non-divisible investments. For the same reason, they are unlikely to be invested in highly risky projects. Consequently, the reduction in precautionary saving that one would expect to result from better sharing of risk need not subtract from investment and risk taking. A fall in precautionary saving might seriously hurt investment only if financial institutions exist that permit the poor to keep their wealth in liquid form while channeling the mobilized resources to high risk, high return investments. Such financial intermediaries are typically lacking in poor rural areas and when they are present they do not always protect small depositors against aggregate financial risk.

In addition, risk sharing may decrease precautionary savings against idiosyncratic risk but accumulation is still required to deal with collective risk: when a drought hits a region, pooling risk with neighbors and friends does not make more food available locally. In these circumstances, it would be foolish for rural communities to set up risk sharing arrangements that discourage any type of accumulation. In fact, such a community would not survive very long in the harsh conditions faced by most poor rural communities of the world today.

Communities might, however, restrict accumulation by some and favor accumulation by others. Too much accumulation by the lower echelons of rural society might indeed challenge the established social order in ways that are deemed undesirable by the higher echelons of society or even by society at large, if they fear the social and political unrest that would follow an erosion of, say, the power of village chiefs. To prevent this from happening, the rural establishment may seek to expropriate successful individuals from the fruits of their success. This process, however, is distinct from the idea of risk sharing *per se* and it must be analyzed separately. To this we now turn. We begin with a discussion of patronage.

5.4 Patronage and inequality

Risk sharing between individuals of different income potential need not lead to an equalization of their *ex post* consumption levels. In fact, one would expect the rich to refuse sharing risk in ways that reduce their expected utility. It can even be shown (see Chapter II) that a sufficiently risk neutral individual will always oppose even a balanced (i.e., non redistributive) mutual insurance scheme. A fortiori, such an individual would reject a scheme that calls for net expected transfers from the rich to the poor (see also Hoff (1996)). Risk sharing can, however, be organized in such a way as to compensate the rich for insuring the poor. This arrangement is called patronage and was already discussed in Chapter II (see also Platteau (1995a, 1995b)).

In patronage, the rich collect the equivalent of an insurance premium from the poor, usually in the form of frequent small payments and services. Extreme forms of patronage include debt peonage and labor bonding, but patronage can also take a more benign, paternalistic form. Irrespective of the form it takes, however, patronage naturally reinforces inequality in society (see also Carter and Zimmerman (1996)). It is thus false to argue that risk sharing inhibits risk taking and accumulation: patronage as a form of risk sharing in fact favors the accumulation of wealth by a few who then patronize less fortunate members of society. The key issue is thus whether societies may fear the concentration of wealth and power that is likely to result from the unchecked development of patronage.

5.5 Egalitarian norms

As discussed in Part I, unchecked accumulation of factors of production in societies with a lot of risk can totally modify the social structure and rapidly lead to a highly differentiated and highly conflictual society. In anticipation, societies may try to prevent the excesses of factor accumulation by imposing egalitarian norms. One way is to institute rituals that periodically waste all wealth, such as the *potlach* rituals among Northeast native American tribes and other rituals that call for the massive consumption of food, beer, and livestock at regular intervals. This works well in static societies; but of course it is no good in a growing society where capital must be accumulated. Another way to do so is to prevent transactions on factors of production through, for instance: the prohibition of slavery, indentures, and labor bonding; the prohibition of usury, to reduce debt peonage (see Chapter II); and the prohibition of land sales to people from outside or even inside the community, as is common in much of Africa (e.g., Platteau (1992), Atwood (1990), Gavian and Fafchamps (1996)). These issues were discussed in detail in Chapters II and III.

Yet another way to discourage the accumulation of assets is to encourage patronage -- of the arts, of the church, and of the poor (e.g., Ellsworth (1989)). So doing, the physical wealth of the rich gets redistributed periodically. In practice, however, patronage is seldom an avenue to egalitarianism. Giving away one’s wealth often amounts to investing in a relationship that can become a source of additional wealth in the long term. Unless one recognizes the long term benefits the rich derive from patronage, it might be erroneously concluded that it is a tax imposed on the wealthy.

In societies where patronage is the dominant avenue to upward social mobility, wealth is often seen as return to help and networks, not return to effort and risk taking. A wealthy person is someone who has helped many, can help them again, and can count on their gratefulness. Fafchamps and Minten (1998), Fafchamps and Minten (1998), for instance, show that relationships and social capital are essential to success in grain trade because it gives access to trade credit and regular supplies and facilitates the conduct of business. Similar examples can be found in the political economy literature under the name of prebendalism (e.g., Bayart (1989)). The reason why patronage is an avenue to individual prosperity is that giving obligates the other party to reciprocate, and that what is reciprocated is more valuable to the patron than what is given away. Whenever these conditions are satisfied, giving is nothing but an investment in social capital and it becomes the surest route to power.

5.6 Social structure and patronage

That patronage is encouraged need not imply that it is encouraged for everyone: certain individuals may not be recognized the right to become a patron. This is hardly surprising since patronage is a source of power. Those in power will probably resent any intrusion on their territory and seek to protect their dominant position. To that effect, norms of social stratification are likely to be invented that make it difficult to challenge power -- such as castes, nobility, hereditary chiefdom, etc. Current patrons may also attempt to undermine challengers by syphoning off, in the name of risk sharing and egalitarianism, any extra wealth that could potentially be used to create a concurrent network of clientelistic relationships.

If successful, these attempts undoubtedly tax risk takers and innovators who are not member of the rural elite. But it would be ill-advised to blame risk sharing for this state of affairs: self-preservation of power is the reason. Besides, even in the absence of risk sharing institutions and egalitarian norms, the rich and powerful are likely to protect their power by whatever ways are available to them, e.g., by restricting access to land, credit, and labor and by imposing an extra corruption burden on outsiders. These are manifestations of power struggle, not of risk sharing.

5.7 Patronage, accumulation, and returns to scale

It should be clear that patronage *per se* need not work against accumulation by society at large. Abstracting for a moment from social capital, patronage reduces the concentration of individual wealth since it forces the redistribution of material goods from those who have to those who have not (see, however, Ellsworth (1989)). But redistribution by itself does not eliminate wealth. The question then is, does the existence of norms of redistribution of material wealth serve as a disincentive to accumulation by individuals?

We have already discussed the favorable role that the insurance provided by risk sharing should have on investment. We now focus on the role of accumulation as a source of prosperity. Since the redistribution of material wealth implied by patronage and norms of redistribution operates as a tax on economic success, it appears that the existence of patronage ought to reduce incentives to accumulate. Incentives to accumulate thus appear smaller than they would be in an idealized capitalist society. This is forgetting that patronage gives access to power and enables individuals to accumulate social capital. The prestige and connections acquired through gift giving require that material wealth be generated, if only to be redistributed. It is thus far from clear that a patronage system creates less incentive to produce and invest than a more individualistic system where economic agents consume the material wealth they generate. A patron cannot succeed without ’stuff’ to give away and, to the extent that giving is the source of power, patronage is probably as potent a stimulant for output than capitalism.

The problem created by patronage is elsewhere. In a society with norms of redistribution of material wealth, it is difficult for single individuals to accumulate large quantities of investable funds. In the absence of returns to scale, this is not problematic: financial capital gets redistributed and facilitates the creation of myriads of small enterprises -- what is commonly known as the informal sector (e.g., Fafchamps (1994)). If returns to scale are decreasing, the redistribution of financial capital is even efficiency enhancing from a social welfare point of view. However, the dilution of capital brought about by patronage makes it difficult to take advantage of investment opportunities that benefit from large economies of scale, such as automobile manufacturing or steel mills. The reason is that no single individual is able to accumulate enough money to make large-scale, non-divisible investments. Incrementalism is the rule.[85] Consequently, one would expect societies where patronage is strong to experience difficulties forming a domestic capitalist class and financing large-scale investments with local private funds. A natural response to this state of affairs is likely to be increased state intervention. Many poor countries, in Sub-Saharan African and elsewhere (e.g., Indonesia), fit this description fairly well, except that they often have a ethnically foreign business class (e.g., Fafchamps (1998)). Prebendalism and political networks of clientelism can thus be seen as efforts by patronage-based societies to enlist the help of the state to mobilize large-scale resources and capture economies of scale. Whether these efforts are ultimately successful in bringing about sustainable growth in large-scale business remains a hotly debated question (e.g., The World Bank (1993), The World Bank (1981)).

There is, however, a form of capital the accumulation of which is facilitated by patronage and risk sharing, namely, social capital in the form of networks. Returns to social capital are highest in information intensive activities such as trade (e.g., Fafchamps and Minten (1998), Fafchamps and Minten (1998)), but the available evidence suggests that they are also present in manufacturing (e.g., Barr (1997), Fafchamps (1998)). An immediate corollary is that societies in which patronage and thus social capital (networks, trust) is strong should prosper in activities that are intensive in social capital such as trade. The available evidence indeed suggests that merchant networks are strong even in countries with little or no large-scale manufacturing, such as most Sub-Saharan African countries (e.g., Meillassoux (1971), Bauer (1954), Jones (1959), Staatz (1979), Amselle (1977), Cohen (1969)). Similar forces operated in the ancient world (e.g., Braudel (1986), Putnam, Leonardi and Nanetti (1993), Greif (1993), Greif (1994)) and are at work in other parts of the world as well, as evidenced by the success of ethnic Chinese communities throughout East and South-East Asia.

Whether or not patronage and norms of redistribution are detrimental to accumulation and growth thus depends on the relative roles of financial and social capital in the development process: if finance is the key constraint, then patronage is detrimental to growth; if, however, social capital is ultimately more important, then patronage can potentially play an important role in linking up key economic actors and building up essential economic networks. Experience suggests that large scale investments are not a foolproof recipe for growth, as the Stalinist experiment in Russa and Korea's recent problems have shown. Good international contacts and to capacity to build local networks are as well if not more important (e.g., Piore and Sabel (1984), Putnam, Leonardi and Nanetti (1993)). Given time, patronage-based societies might build the international links that are essential for access to information and markets in developed countries. When they do, they will undoubtedly surprise us.

[85] A good illustration of incrementalism is the mass of unfinished houses that dot the landscape of most developing countries.

CONCLUSIONS

We now take stock of what we have learned about the relationship between risk, rural poverty, and economic development We also make suggestions regarding future work and policy intervention. A special emphasis is put on identifying current gaps of knowledge and areas where empirical work is most needed to support or vindicate recent theoretical developments.

Section 1. What We Have Learned

We have learned that risk affects the rural poor in numerous and profound ways. The magnitude and range of shocks that affect rural populations of the Third World is without comparison in developed economies. Perhaps the only way to describe it to people who have never been there is to compare it to a war economy: death strikes at random a large proportion of the population, espacially children; the provision of health services is either inexistent or insufficient; trade with the rest of the world is difficult so that many commodities are rationed or unavailable and local prices are erratic; food is at times very scarce; and steady wage employment is inexistent so that people must make a living from self-employment in little jobs. To deal with such a harsh environment, people are equipped with very little in terms of advanced technology and accumulated assets. Financial institutions are either absent or inefficient and expensive, and in many places, inflation is rife so that the cost of hoarding money is high.

In response to these extremely difficult conditions, rural societies have developed sophisticated ways to cope with risk. These multi-faceted strategies include: settling relatively safe areas; breeding plants and species that survive in difficult environments; diversifying sources of income; preserving flexibility and keeping options open; accumulating precautionary saving; forming strong and large households; seeking the protection of the rich and powerful; and sharing risk with a large network of friends and relatives. These strategies are subject to serious technological, environmental, and economic constraints that limit their effectiveness. Furthermore, rural societies often prohibit individually rational options such as distress land sales, labor bonding, and debt peonage, because they would generate unacceptable inequality and social tension in the long run.

Commitment failure seriously limit society’s capacity to share risk. Institutions have developed that provide partial solutions to this problem. Corvée labor can be used by traditional chiefs to set up a village welfare fund. How effective such efforts are ultimately depends on the leadership and integrity of the chiefs themselves. A similar comment can be made about the social programs of numerous churches and NGO’s. Family law, whether modern or traditional, establishes a strong bond between spouses and between parents and children and penalizes those who seek to avoid their family responsibilities. Family values are a key element of the rural poor’s strategy to deal with risk; loyalty to the family is seen as a fundamental civic virtue. The failure to abide by these values often results in personal disaster.

Commitment failure is also mitigated by forming long-term relationships with networks of friends and relatives. These relationships, however important in helping the poor deal with risk, are not perfect: self-interest motives introduce distorsions that preclude a fully efficient sharing of risk. Widespread reliance on quasi-credit contracts instead of income pooling or contingent transfers is a sign that self-interest and commitment failure shape the form taken by mutual insurance. Efforts to minimize incentive problems induced by information asymmetries also reduce the effectiveness of mutual insurance, for instance by limiting coverage to observable events or providing partial insurance to limit moral hazard. Moral norms and village ideologies can be seen as attempts to penalize inefficient opportunistic behavior and to induce truthful information revelation and, hence, to mitigate the perverse effects that self-interest and information asymmetries have on mutual insurance.

We have also learned that the relationship between risk, poverty, and economic development is complex but that our understanding of the underlying processes has progressed dramatically with recent theoretical and empirical advances. We saw that rural poverty by itself is unlikely to raise net fertility, that is, the number of surviving children per woman. We argued that chronic poverty, by itself, seldom leads to starvation -- except in cases of extreme destitution. Its negative impact on welfare comes mostly from the fact that it dramatically raises the vulnerability of individuals and households to adverse shocks. The effects of these shocks manifest themselves not only in terms of short-term and long-term nutritional status but also in terms of morbidity and mortality rates. The evidence further suggests that populations that are ill and poorly fed cannot operate effectively and fail to reach their full potential. We also reported recent evidence indicating that the poor find it difficult to keep their children in school. As in the case of nutrition and health, the role of income shocks was also brought into light in the sense that a single negative income shock appears to have as much negative effect on schooling as permanent poverty (e.g., Sawada (1997)).

Next, we discussed the relationship between rural poverty, risk, and technological innovation. We argued that Sandmo (1971)'s traditional explanation for the poor's reluctance to invest in risky technologies -- namely, their aversion to risk -- does not survive close scrutiny. In its stead, we propose a distinction between several distinct processes. First, we argue that if inputs are provided by the producer himself or herself, such as land, labor, and livestock manure, Sandmo's reasoning no longer applies: faced with the choice between enjoying leisure now and starving later or investing time in a risky activity such as crop production, risk averse households naturally choose to take risks and produce. Second, if production requires purchased inputs such as improved seeds, fertilizer, or pesticides, poor households might refrain from producing not because they are risk averse but more simply because they do not have sufficient funds. Furthermore, even if they have access to credit for these inputs, they might still refrain from purchasing because they fear bankruptcy. In this case, it is not so much the variance of output *per se* that is an issue but rather the fact that output might be insufficient to cover input costs. We provided three examples of mechanisms that provide credit for modern inputs and eliminate the risk of bankruptcy without eliminating production risk. These mechanisms have been successfully used for input delivery in different contexts, suggesting that bankruptcy risk might be a more useful concept to understand technology adoption than risk aversion.

Next, we turned to the diversification argument and noted that the poor's desire to diversify ought to favor adoption of new technologies. In fact, based on the diversification argument alone, we argued that risk averse farmers should be more -- not less -- likely to adopt new technologies that are divisible and do not require massive cash outlays. Only when the new technology is non-divisible (e.g., tractor, animal traction) does risk aversion operate against adoption. The desire to diversify was also seen to operate against full specialization in a single technology, whether old or new. As a result, diversification reduces the gain from technological innovation. One should therefore not blame risk aversion *per se* for the non-adoption of divisible technologies such as fertilizer and improved seeds.

We then discussed the relationship between poverty, risk, and experimentation with new technologies. We noted that, by the diversification argument, poor farmers ought to be quite willing to experiment with new techniques of production as long as this can be done on a small scale. The reason is that new technologies provide new avenues for diversification and that diversification has more value for risk aversion producers. However, when experimentation and learning are non-divisible, they conflict with the poor's desire to diversify, which singularly reduces their appeal. To summarize, we identified the non-divisibility of technology and its learning process as a major stumbling block on the road to adoption by poor farmers. The variance of output appears, by itself, unimportant, except inasmuch as it raises fears of bankruptcy. The main factors that hinders technology adoption by poor risk averse farmers thus appear to be: large cash outlays, loss of diversification after adoption, and large risk during experimentation and learning.

Next we focused on the observed regularity that larger farmers in the Third World are more cash crop oriented and smaller farmers more food crop oriented. Using a simple model of crop portfolio decision with income and consumption price risk, we showed that conditions prevailing in rural communities of the Third World tend to reproduce the observed relationship between farm size and cash crop cultivation. The intuition behind the approach was simple: rural food markets in poor countries are thin and isolated, leading to a high variance in food prices and a high covariance between individual and market supply. Staple consumption, on the other hand, is essential for survival. Consequently, staple food expenditures have a low income elasticity. The combination of both elements leads to a situation in which food *security* at the household level is best achieved by a high degree of food *self-sufficiency.* Large farmers differ from small farmers not only in better access to credit and their better ability to sustain risk, but also in the lower share that staple foods represent in their total consumption expenditures. The model presented in Chapter IV suggested that this alone can account for the observed regularity between farm size and cash crop cultivation.

We then proceeded to illustrate how market integration progressively diminishes the need for food self-sufficiency. As better roads and transportation equalize price movements across a larger regional or international market, food prices become increasingly dissociated from local supply and demand conditions. All the effects of market integration - a lower variance in food prices, less covariance between individual output and aggregate supply, a more elastic demand because of substitution and international trade possibilities - were shown to reduce an individual's rationale for food self-sufficiency. Our analysis also predicted that large farmers would have a higher price elasticity of cash crop supply, and that small farmers would have a higher price elasticity of food crop production. The integration of food markets thus appears an essential ingredient to agricultural modernization.

We then turned toward credit constraints and precautionary saving. What motivated our analysis was the simple observation that, although the poor might not afford a non-divisible investment today, by saving enough they ought to afford it tomorrow. Consequently, credit constraints ought to constitute only a temporary obstacle to investment. We argued that this observation is correct but very misleading. To that effect, we showed that, when the poor use their limited liquid wealth to smooth consumption and deal with consumption shocks, they might resist investing all of it in an irreversible investment. We showed that this was the case even if investing results in an income stream that stochastically dominates the original distribution of their income. In other words, resistance to investment had nothing to do with risk aversion as normally defined: in a Sandmo (1971) setup (see above), any risk averse individual would choose the income stream that stochastically dominate the others; this is not the case when the investment is irreversible and the poor save for precautionary reasons.

Using parameters estimated from samples of investments in wells by Indian farmers, we showed that poor individuals with a precautionary motive for saving find it very hard to save enough to finance a large lumpy investment. The reason is that income and consumption shocks nearly always hit them before they have had the time to accumulate enough for the investment. This is true even though the poor respond to the presence of an investment opportunity by saving more. As a result, the probability of investing is very low and the average time to investment extremely long. To summarize, although the law of martingales implies that eventually everyone invests, 'eventually' can be an awfully long time -- much too long to wait for.

The link between poverty and low investment apparent in these results is reminiscent of 'vicious circle' and 'big push' theories of development propounded decades ago by Nurkse (1953), Lewis (1954), Nelson (1956), and others. Modern versions of these theories can be found in Gaylor and Ryder (1989), Murphy, Shleifer and Vishny (1989), Fafchamps and Helms (1996) and Barro and Sala-I-Martin (1995). These issues deserve more empirical research at the village and household level.

In the final part of Chapter IV, we discussed the relationship between risk sharing and risk taking. In Chapters II and III we saw that the sharing of risk among members of a rural community is an important way by which the poor deal with external shocks. The end of Chapter IV examined whether the sharing of risk serves as a disincentive to invest, as some have recently argued. We first pointed out that the insurance component of risk sharing ought to favor investment, not deter it, for the simple reason that better insured investors are less vulnerable to unfavorable investment outcomes and thus are more prone to invest. Risk sharing is, however, likely to reduce the need for precautionary saving. Consequently, members of risk sharing networks ought to lower their holdings of liquid wealth. We nevertheless pointed out that liquid assets are still necessary to deal with collective shocks, and thus that precautionary saving would still be required. In addition, we know that precautionary saving is often kept in a form that is both highly liquid and not very productive. Unless the poor save mostly at the bank and financial intermediation is efficiently organized, a lowering of precautionary saving is unlikely to significantly reduce productive investment.

Next we discussed how norms of redistribution of material wealth coupled with the need to share risk with others leads to patronage systems in which the better off protect the weaker members of society against adverse shocks. We noted that communities subject to lots of external shocks might fear the concentration of wealth that would naturally arise, were asset and credit markets allowed to freely develop. We pointed out that, in order to ensure long-term social cohesion, these communities might come up with egalitarian norms that prohibit certain types of transactions and require the redistribution of material wealth. We argued, however, that these norms need not preclude the accumulation of social capital in the form of networks of reciprocal obligations and debts of gratitude.

We then investigated whether egalitarian norms of redistribution dilute incentives to invest. We noted that generating material wealth is essential to build up social networks of patronage through redistribution. Consequently, incentive to invest and create wealth exist as long as patronage as a form of social upward mobility is an option open to everyone. It remains unclear, however, whether these incentives are as strong as those that exist when individual consumption of material wealth is the primary objective of success. Incentives to invest may nevertheless be lowered if certain individuals are not allowed to rise socially. In this case, 'taxation' by society in the form of forced redistribution, theft, and pilferage becomes a potent disincentive to accumulation and risk taking. That this might be an issue in many poor rural areas of the Third World is implied by the fact that ambitious young men and women often leave the countryside and go to the city where there are fewer obstacles to individual success. The rigidity of social structure might thus be an obstacle to risk taking, especially by young individuals more open to modern techniques of production. In this sense, progress might indeed be held back.

We concluded Section 4 by noting that patronage as a system of social stratification makes it difficult for single individuals to accumulate large sums of money. Consequently, large investments are not undertaken. If returns to investment are decreasing or constant, this is not a problem: redistribution of material wealth facilitates the creation of myriads of microenterprises, which is precisely what we observe in many poor countries. However, the dilution of capital brought about by patronage makes it difficult to take advantage of investment opportunities that benefit from economies of scale. Social stratification based on patronage is thus likely to be inimical to large scale industrialization. In contrast, patronage favors the accumulation of social capital, an essential ingredient in trade. Patronage-based societies might thus constitute a favorable breeding ground for trade-based activities, provided the right kinds of contacts can be established with the outside world.

Section 2. What We Do Not Know

We have learned a great deal about risk coping by the poor but there is still a lot we do not know. Casual observation tells us that patterns of settlement partly match the relative safety of specific environments in terms of human and livestock health. Migration studies show that the poor move out of unwelcoming areas in large numbers and travel far and wide in search of better living conditions. We also know, simply by watching television, that drought, warfare, and other natural catastrophes throw scores of people on the roads in search of safety. Yet it is not fully understood what makes people live where they live.

It is more and more obvious that, in due time, large areas of the earth that are currently populated will eventually be depopulated, in particular wide tracks of inhospitable mountain, desert, marshes, and rainforest. Eventually, people will move, as they should, away from fragile, marginal areas toward lands suitable for urban settlement and intensive agriculture. This movement should be understood in order to be facilitated. It is where people are not moving that pockets of rural poverty will remain the longest. Efforts to stabilize poor populations on fragile lands are ill advised as they contribute to the perpetuation of rural poverty.

The recent abundance of theoretical and empirical work on precautionary savings has brought to light the role of asset accumulation as a hedge against risk. It has shown that the poor are willing to save, even at negative interest rates, and thus that they are penalized by inflation and by financial repression that keeps returns on savings accounts artificially low. Although there has been a lot of work on credit markets in poor rural areas, there is a dramatic dearth of work on savings and on the use of financial instruments by the rural poor. The few empirical studies that exist, however, show that the provision of financial institutions in rural areas help the poor save. Reconstruction of cash balances of rural households, although highly speculative, indicate that money may be a more important savings instrument than is often recognized. Precious little is known on how the rural poor use money and other financial instruments. More work is needed so that adequate savings instrument can be provided.

Economists are only beginning to recognize the paramount importance that the household formation process has on poverty. In this study, it has been argued that one of the primary functions of households is to form teams of people who can deal with shocks together and help each other in difficult times. It has also been hypothesized that households can be broken by traumatic events and that the dissolution of households almost always has negative repercussions on its former members. Yet very little is known on how households form and, even more importantly, how they break apart. Rural household surveys typically follow existing households and ignore isolated individuals who eke a living at the margin of rural communities or join the ranks of a highly mobile urban proletariat. Households that break apart are often dropped from survey rosters and no information is collected on the fate of its former members. As a result of these biases, we know very little about the effect of household dissolution on poverty and risk coping. The little bit that we know, however, is troubling: female headed households in rural areas are nearly always worse off than households where both spouses are present. More work is needed to understand the factors that favor stable and successful households in spite of external shocks.

We also need to better understand how resources are allocated within households themselves. The evidence suggests that households deal with shocks by reallocating scarce resources to its productive members. Women seem to pay the price of such a strategy because their traditional function is reproduction, and investment in children is a low priority when a household can barely feed its current members. More research is needed to confirm that this interpretation is correct and that it can account for the often observed nutrition deficit of poor rural women. In particular, we may wish to find out whether these nutrition and health outcomes are optimal and desirable from the point of view of women themselves.

Recent work has shown that networks of long-term relationships help mitigate commitment failure not only in risk sharing, but also in other forms of exchange. The importance of networks has long been recognized in other social sciences but the time has now come for economists to examine the role that networks play in the sharing of risk. More needs to be known on how networks are formed and how they fall apart. It is indeed becoming increasingly clear that individuals with few friends are at a disadvantage in a rural world fraught to danger. Social network capital should thus be viewed as a crucial factor affecting and being affected by poverty and shocks.

Much recent work on risk coping by the poor has been extremely naive regarding the role of inequality and power. Yet observers of poor rural societies consistently warn us that desperate people will do anything to buy time, including mortgaging their own future survival. We have seen that the sharing of risk between the rich and the poor has a natural tendency to become exploitative and to foster inequality. We need to take a harder look at the interplay between power and risk. Judging by the legal prohibitions many rural societies have come up with to discourage distress sale of productive assets such as land and labor, these issues are important to the people involved and they deserve empirical enquiry.

Finally, although we have made much progress in our understanding of individual risk coping strategies, we still know very little about how they interact with each other. One issue that has received some attention is that of the relationship between individual asset accumulation and explicit risk sharing. We have seen that much pooling of risk can be achieved when individuals hold precautionary savings and can trade their assets for consumption goods in perfectly competitive markets. We have also argued that self-interest may discourage individuals from participating in risk sharing arrangements if the expected gains they make from sharing risk are not commensurate to what they are asked to contribute. Intuitively, this creates a tension between risk sharing and precautionary saving: if the latter is easy and cheap, this lowers the expected gain from explicit risk sharing, and thus the contributions individuals are willing to make to help others. One may therefore fear that introducing better precautionary savings instruments can undermine existing risk sharing arrangements. This issue deserves more theoretical and empirical investigation.

Regarding the effect of risk and rural poverty on economic development, we have cast doubt on the idea that the poor's concerns for old age security increases fertility rates net of infant and child mortality. Efforts to ensure the old age security of the poor, although favorable to their welfare, are unlikely to have a significant effect on demographic pressure. This issue deserves further investigation.

Recent research indicates that temporary income shocks are as damaging for school attendance as chronic poverty. This suggests that school drop-out rates could be dramatically curtailed by helping the poor deal with temporary shocks. Future research should seek to assess the best way to achieve this purpose in a financially sustainable manner.

We have demonstrated that the idea that the poor resist innovation simply because they are risk averse is far too simplistic. A better understanding of the available theory and empirical evidence suggests instead that the poor worry about not so much about the variation of income *per se*, but rather about keeping a sufficient buffer of liquid assets to deal with emergencies. Consequently, they are unlikely to invest whatever assets they have in inputs and equipment that must be paid up front. Our analysis suggests that successful dissemination of purchased inputs requires a combination of credit and insurance. Further investigation is needed to identify input delivery systems that are well adapted to the needs of poor producers.

We have argued that the poor's desire to diversify ought to make them quite receptive to divisible technologies such as seeds, fertilizer, and pesticides. Instead of encouraging the adoption of combined packages on a whole farm, the analysis presented here suggests that experimentation with small quantities on small plots is a better way of getting poor producers interested in new technology. This issue requires empirical confirmation. We have also shown that food price volatility raises poor farmers' concerns for food self-sufficiency. More research is needed to measure how strong these concerns are and how much they distort production choices.

Finally, in Chapter IV, we argued that societies which impose norms of material wealth redistribution favor patronage as a mode of social differentiation. We further indicated that, if this is the case, norms of redistribution ought not to be perceived as obstacles to saving and investment because generating material wealth is necessary to build one's social network. Whether this is true in practice requires serious empirical investigation. More work is also required to identify the types of social capital that is most necessary for growth.

Section 3. What Local Governments Can Do

Keeping in mind that there are still many unresolved issues regarding risk coping by the poor, what we already know or strongly suspect suggest a number of policy interventions. We discuss them briefly here.

1 It is important that government do not stop natural migration and resettlement out of marginal areas. In the past, governments have often been tempted to fixate populations in what is perceived to be their traditional habitat. Scarce national resources would be better spent developing high potential areas and encouraging people to move there. This means draining marshes, clearing forests, setting up irrigation infrastructure, and building roads into areas with a high agricultural potential. Inciting people to relocate into such areas also requires vigorous efforts to eradicate malaria, trypanosomiasis, and other parasitic human and livestock diseases.

2 By the same token, government should stop trying to move rural populations to marginal zones in ill-advised "relocation schemes", such as the development of the Amazon, the new economic zones in Vietnam, or forced resettlement in Ethiopia.

3 In countries where high agricultural potential areas are inexistent or already overcrowed, such as some of the Sahelian countries or the Rwanda-Burundi region of Africa, agriculture may be unable to absorb population growth. In this case, government may want to consider either helping their surplus population to emigrate abroad, or anticipating the growth of the urban periphery and the need to provide poor urban migrants with decent public services.

4 We saw that, under conditions of extreme duress, the poor may adopt risky or even suicidal strategies. One such example is the chaotic movements of famine-striken people in search of food along roads and across country boundaries. These movements often are dangerous, as they separate families and put them at the mercy of bandits and rogue armies. Relief efforts should try to anticipate these movements by distributing aid before panic sets in and households leave their village. This requires, for instance, the continued presence of famine early warning sytems and the existence of well defined procedures and relief agencies equipped and trained to deal with emergencies on short notice.

5 Governments should move away from an exclusive emphasis on rural credit and turn to rural savings. This is particularly relevant given evidence that the rural poor rely less on livestock sales to deal with risk than was previously believed. Adequate savings instruments should thus be made available to the poor. This requires setting up clear and rigid prudential guidelines for rural savings and loan associations, and penalizing those who profit by establishing pyramid schemes that defraud the poor.

6 Governments should renounce to using the inflation tax to finance their deficit. Financial repression is counterproductive in that it lowers the return that the poor get on their precautionary saving.

7 Governments should favor the geographical integration of grain and livestock markets. Barriers to trade across regional and international boundaries should be removed and road blocks should be dismantled. Veterinary services should be provided to herders in a cost-effective manner.

8 Governments should focus the provision of health services on prevention and the delivery of cost-effective health services. They should also favor the provision of safe drinking water. Expensive treatments such as those required by AIDS patients are beyond the reach of most poor countries. Until a cheap treatment of AIDS becomes available, scarce resources are better used for the prevention and treatment of curable tropical diseases, such as malaria, measles, bronchitis, tetanus, gastro-intestinal infections, and the like.

9 Governments should launch campaigns to eradicate malaria and other parasitic diseases. Due to the public good nature of eradication, only a massive coordinated campaign can succeed.

10 Wild animals and their habitat are reservoirs of dangerous diseases and parasites. Elephants, wild buffaloes, and crocodiles are also notorious for trampling crops and killing children every year. Governments should ensure that efforts to protect wildlife do not impose too high a cost on neighboring communities.

11 Governments should provide a safety net for those who have fallen outside the protection of village-level, relationship-based risk sharing arrangements. This includes orphans, abandonned, and runaway children; old people without relatives to care for them; permanently disabled individuals rejected by their family; and victims of domestic

violence. These programs must be designed in such a way that they do not generate perverse incentives and undermine family solidarity.

12 Governments should pursue agricultural intensification and seek new products and new international markets for their products. In the long run, rural poverty can only be eradicated by economic development.

13 Policy instruments such as relief fellowship programs should be developed and tested that help the poor bring and keep their children in school in spite of temporary exogenous shocks. School-based feeding programs may also assist in keeping children in school in spite of consumption shortages, thereby opening an important way for governments to provide insurance to the poor while improving human capital.

14 Governments should seek to eliminate exploitative forms of relationships between rich and poor. Child labor in sweat shops and child prostitution are examples of such practices that have attracted a lot of public attention lately. Eradicating these practices is complicated by the fact that the poor may willingly accept exploitation as the only way to survive. In the case of child labor, poor parents may effectively ’sell’ some of their children to feed the rest of the family or finance their way out of poverty. In these circumstances, repression alone is unlikely to work, and may even make things worse. What is needed is a comprehensive effort to help victims overcome the circumstances that led to exploitation in the first place.

15 The suspicion that women bear the brunt of food shortages at the household level has implications for food targetting, especially during famines, but also on a more regular basis. For instance, governments should open food-for-work and other public works schemes to the participation of women.

16 Delivery systems for purchased inputs should include two essential components: a credit component, so that the liquid wealth of the poor remains at their disposal to deal with income and consumption shocks; and a contingent default clause, so that nothing has to be paid if output is zero. Methods should be investigated that achieve these objectives without generating too much opportunistic default.

17 The dissemination of divisible inputs such as improved seeds and fertilizer ought to encourage small scale experimentation by the poor instead of pushing large comprehensive packages.

18 The integration of food markets should be pursued through better roads and transportation and the removal of policies and institutions impeding domestic trade such as road blocks and cross-regional trade barriers. Government sponsored shops providing cheap food may also provide a partial answer to small farmers’ food self-sufficiency concerns.

19 Because of their concern for food security, technological change in cash crops alone will fail to attract small farmers. Agricultural research should concentrate on promising food crops as well as cash crops.

20 Credit is the principal avenue through which the poor can invest in large non-divisible assets such as irrigation equipment. Credit need not cover the entirety of the investment cost, nor does it require a subsidized interest rate. What appears more important is that debt relief be made available when adverse shocks occur, and that access to credit be as predictable and widespread as possible, so that the minute the poor have accumulated enough liquid assets, credit is granted without delay and the investment is undertaken. Otherwise, liquid wealth will dissipate due to exogenous shocks.

21 Investment can be facilitated by putting better saving instruments at the disposal of the rural poor. Although the poor are typically willing hold onto liquid wealth in spite of negative returns, low returns on the poor’s savings makes it harder for them to accumulate enough to invest and is thus detrimental to growth.

22 Government should seek to bring credit closer to the poor by experimenting with various forms of contingent or insured credit. How this can be achieved is still unclear at this point, but it may involve a combination of flexibility in debt repayment, innovative use of collateral, and group lending.

23 Efforts should be made to ensure that the rural structure is willing to accept the success of entrepreneurs and innovators. Oppression by the old and the powerful is not conducive to rural investment and entrepreneurship.

24 Efforts to dismantle patronage networks and favor western-style individualism are probably futile as they undermine risk sharing institutions that are deemed important by the societies concerned. One should instead strive to invest in the kind of social capital that is most needed for growth.

Section 4. What the International Community Can Do

The role of the international community is twofold. First it serves a redistributive role by assisting governments of poor countries take care of the poorest and most vulnerable segments of their population. In performing this role, the international community should strive not to let the domestic political debates of rich countries dictate what kind of assistance is given to poor countries. Laudable concerns for the fashionable moral principles of the day too often lead developed countries to patronize their weaker southern neighbors and impose upon them whatever political agenda is most in vogue at home. For instance, scandals about the funding of political organizations in developed countries spills over into condemnation of corruption abroad. Concerns for women and the environment translate into gender and environmental conditionality. This conditionality is often embraced by recipient countries -- and imposed by donors -- with a great deal of hypocrisy. Such patronizing behavior is unbecoming of international relations between sovereign countries. Besides, the lesson givers seem to forget that, not long ago, they were themselves corrupt, kept women in a state of dependence, and pillaged their environment for profit. The international community should learn not to let the domestic political agenda of rich countries get in the way of assistance to the poor.

The international community serves a second, more important role: the provision of international public goods. Here are some examples of practical ways in which it can help the rural poor:

1 The international community should continue to serve its role of planet-wide risk sharing and help governments deal with massive crises trigerred by natural and man-made catastrophes: droughts, warfare, genocide, floods, earthquakes, etc. The effectiveness of these efforts could be improved if the collaboration of local governments can be secured beforehand, that is, via the establishment of local relief agencies with the right expertise in targetting and delivery. This requires long term collaboration with local authorities.

2 Relief efforts of the international community often are jeopardized by military conflict on the ground. It might be worth exploring the idea of penalizing the hindrance of relief operations and the diversion of relief aid for political or military gain. Indeed, interfering with relief efforts often results in unnecessary death and suffering, sometimes more so than warfare itself (e.g., Biafra, Ethiopia in 1984, Southern Sudan). Making it a crime

to divert or prevent the distribution of food aid would pave the way for the newly created International War Crime Tribunal to seize itself of such cases. This would reinforce the protection that are already imparted by treaty to international bodies such as the International Red Cross and HCR.

3 More funds should be chanelled into research for a malaria vaccine. It is a scandal that malaria resistance to new prophylactic drugs spreads so quickly even though these drugs are in practice only used by a tiny proportion of the population. It is as if nobody cared as long as a new generation of drugs can be found in time to protect expatriates. Clearly, the rural poor will be protected from malaria only when a suitable vaccine is discovered and produced in large enough quantities to reduce production costs.

4 Research on an AIDS vaccine is also a top priority. HIV has become a Third World disease and current treatment is outside the reach of the rural poor. Only a cheap vaccine can improve the situation of millions of villagers in Uganda, Tanzania, Zaire, and elsewhere.

5 A massive international campaign to eradicate malaria by the year 2050 should be launched. This effort could be the single most important contribution to reducing the risk faced by the rural poor in Sub-Saharan Africa.

6 A similar effort should aim at eradicating trypanosomiasis (a livestock disease) from West Africa.

7 Locust control efforts should be continued and revitalized.

8 Peace keeping efforts should be pursued more vigorously. The international community should condemn and stigmatize practices of powerful nations whereby they arm factions and groups in poor countries to serve their geopolitical interests.

9 More funds should be go to research on high potential tropical crops such as maize, rice, and cassava. Fewer resources should be wasted on breeding millet and other crops that only grow in marginal areas. In the long run, millet and sorghum will only be used as livestock feed.

10 The international community should assist the efforts of governments of developing countries to gain free access to developed countries for their agricultural products. It is contradictory for developed countries to ask poor countries to increase their agricultural exports while at the same time protecting their domestic markets from what the rural poor could credibly export, that is, grain, meat, sugar, vegetable oils, animal feed, fruits, and vegetables.

11 The international community should help poor countries steer away from inflationary policies that hurt the poor by reducing the value of their meager savings. One avenue to explore is the establishment or expansion of currency agreements such as the CFA Franc zone, or the ’dollarization’ of developing countries, such as the one proposed by Chile. This, of course, assumes that the problems inherent to such agreements can be dealt with satisfactorily.

APPENDIX: PROOFS OF PROPOSITIONS

Proof of Proposition III.1: Each point on the boundary of the equilibrium set can be found by maximizing one agent's expected utilitpi subject to satisfying all participation constraints and maintaining other agents at a given expected utility level. By varying the expected utility of other agents and by repeating the process for all agents, we can span the whole boundary of the equilibrium set. Now, participation constraints with A^1 are a restricted version of participation constraints with A^2. Therefore, by Le Chatelier principle, the maximum expected utility with A^2 lies weakly above what can be achieved with A^2 for all expected utility levels of other agents. Every point on the boundary of $\Omega(A^1)$ thus lies weakly below every point on the boundary of $\Omega(A^2)$. This proves the proposition. Strict inclusion occurs whenever δ and A^1 are low enough for some participation constraints to be binding. A strictly higher A^2 then is sure to release the binding participation constraints somewhat and to strictly enlarge the set of equilibria.□

Proof of Proposition III.2: For any given IRSA τ_s^i, the right hand side of the voluntary participation constraint VP decreases with δ. Consider an arbitrary agent i and state of nature s. Let δ fall to the point where the VP constraint is binding for that i and s. In order to further decrease δ while still ensuring payment of τ_s^i, agent i has to be compensated in other states of nature s'. Compensation by other agents is possible as long as some of their participation constraints are not binding. A lower δ thus forces agents who contributed little and whose participation constraints were therefore less binding, to contribute more. If δ drops further, eventually no agent is left without binding participation constraint.□

Proof of Proposition III.3: We drop i subscripts for simplicity of exposition.

Part 1: *(Case 1)* If $U_i(y) > -\infty$ for all $y > -\infty$, assume that there exist a binding participation constraint for that agent at which he or she does not get his or her highest possible income (A2). *(Case 2)* If $\lim_{y \to y^*} U_i(y) = -\infty$ for $y^* > -\infty$, assume that agent i prefers the probability of a $-\infty$ utility tomorrow than a $-\infty$ utility today (A3). If utility is undefined below a particular value of y, set it equal to $-\infty$. Let $\tilde{y}$ denote the realized income of agent i at the binding participation constraint. Let X stand for the right hand side of the participation constraint $V(\tilde{y}) - V(\tilde{y} - \tilde{\pi})$. Since the constraint is binding and there is risk sharing (A1), the right hand side of the participation constraint is strictly positive and $X > 0$. Construct a concave transformation of $V(y)$ as follows: for all $y \geq \tilde{y}$, lease $V(y)$ unchanged; for all $y < \tilde{y}$, rotate agent i's utility by a factor $k > 1$, i.e., i's utility becomes $kV(y) - (k-1)V(\tilde{y})$.

Case 1: With this new utility function, the right hand side of the participation constraint becomes kX: the utility loss of complying with IRSA obligations has been stretched by a factor k. The right hand side of the participation constraint after the transformation of $V(y)$ can be decomposed into three parts:

$$(k-1)V(\tilde{y})[Pr(y \leq \tilde{y}) - Pr(y - \pi \leq \tilde{y})] + k\int_{\underline{y}}^{\tilde{y}} [V(y - \pi) - V(y)]ds + \int_{\tilde{y}}^{\bar{y}} [V(y - \pi) - V(y)]ds$$

Let the three terms of the above sum be denoted A, kB, and C. The right hand side of the participation constraint before the transformation was simply $B + C$. By (A2), $C \neq 0$. The participation constrainst after the transformation is violated iff $A + kB + C < kB + kC = kX$, that is, iff $k > A/C - 1$. Since A and C are constants that do not depend on k, such a k always exists.

Case 2: If $\lim_{y \to y^*} V(y) = -\infty$ for $y^* > -\infty$, then as one increases k, agent i's utility may fall to $-\infty$ for income realizations in the support of π_s, or for possible consumption realizations $\pi_s - \tau_s$. When this happens i's expected utility falls to $-\infty$ and the construction that we used in case 1 no longer works. It is still possible, however, to pick a k large enough that the utility agent i derives from contributing $\tilde{\pi}$ is $-\infty$. Then, by (A3), the participation constraint is violated.□

Part 2: Let ω_s stand for the probability that the realized state of the world is $s \in \{1, 2, ..., S\}$. By assumption, $1 > \omega > 0$ for all s. Let s' be the state of the world when the participation constraint is binding and let Z_i be the value of the binding participation constraint $V(pi_{s'}) - V(\pi_{s'} - \tau^i_{s'})$. Introduce the following notation:

$$A^i_s \equiv V(pi_s - \tau_s) - V(pi_s)$$

$$\mu^j = \frac{1}{S}\sum_{s=1}^{S} \omega_s \pi^j_s$$

$$\sigma^j = \frac{1}{S}\sum_{s=1}^{S} \omega_s (\pi^j_s - \mu^j)^2$$

Furthermore, let Ω be the vector of probability weights $(\omega_1, \omega_2, ..., \omega_S)$, B^i be the vector $(B^i_1, ..., B^i_S)$, Φ be the vector of income means $(\mu^1, ..., \mu^N)$, Σ be the vector of income variances $(\sigma^1, ..., \sigma^N)$, 1 be a vector of ones, and Ξ and Ψ stand for the $S \times N$ matrices of incomes and squared deviations from income mean.

We know that

$$\Omega' B^i = Z^i$$

$$\Omega' \Xi = \Phi'$$

$$\Omega' \Psi = \Sigma'$$

$$\Omega' 1 = 1$$

We want to show that it is possible to find another set of probability weights $\hat{\omega}_s$ such that each agent faces the same expected income, the variance of each agent's individual income has increased, and agent i's participation constraint is violated. Formally we want to find a vector $\hat{\Omega}$ such that

$$\hat{\Omega}' B^i = Z^i + \varepsilon$$

$$\hat{\Omega}' \Xi = \Phi'$$

$$\hat{\Omega}' \Psi = \Sigma' + \Gamma'$$

$$\hat{\Omega}' 1 = 1$$

where $\varepsilon > 0$ is a scalar and Γ is a vector of strictly positive numbers. The above can be rewritten:

$$\hat{\Omega}'[B^i \ \Xi \ \Psi \ 1] = [Z^i + \varepsilon, \Phi', \Sigma' + \Gamma', 1] \tag{A1}$$

Let ρ be the rank of the matrix $[B^i \ \Xi \ \Psi]$. Clearly, ρ cannot exceed $2N + 2$. Thus if $S \geq 2N + 2$, there exists at least one set of probability weights (several if the inequality is strict) such that equation (6) is satisfied for any arbitrary ε and Γ. Since by assumption the initial probability weights ω_s are all strictly positive, the linearity of equation (A1) implies that there exists a set of numbers ε and Γ such that equation (A1) is satisfied and $\hat{\omega}_s \geq 0$.□

Proof of Proposition III.4: Equation (4) guarantees that punishments deter *ex post* defection from the cooperative path τ_s. Equation (5) ensures that punishments are self-enforcing for the punished agent. Equation (6) ensures that each agent $i \in N$ is deterred from defecting on the punishment of another agent $j \neq i$. Equation (7) guarantees that punishments are not dominated by other paths and thus are weakly renegotiation-proof. Other participation constraints are never binding and can be ignored.□

Proof of Proposition III.5: We drop i subscripts for simplicity of exposition. Define p_s as the scalar that satisfies

$$V(x + \varepsilon_s) - V(x + \varepsilon_s - p_s) = \frac{\delta}{1-\delta} E\left[V(x + \varepsilon_{s'} - \tau_{s'}) - V(x + \varepsilon_{s'})\right] \tag{7}$$

p_s is the willingness to pay for the reduction in risk generated by the IRSA; that willingness to pay depends on the realized state of the world s. Because of decreasing absolute risk aversion, p_s decreases with x for all s (Pratt (1964)).

In the limit, when absolute risk aversion is 0, equation (7) boils down to:

$$p_s = -\frac{\delta}{1-\delta} E\tau_s \tag{8}$$

which is 0 if the IRSA is actuarially fair. Thus $\lim_{x \to \infty} p_s = 0$. Now consider a particular $\tau_s > 0$. By assumption, τ_s satisfies i's participation constraint when $x = \bar{x}$. As $x \to \infty$, however, it does not since willingness to pay has dropped to 0. Therefore, by the continuity of equation (7), there must exist an x^* such that:

$$V(x^* + \varepsilon_s) - V(x^* + \varepsilon_s - \tau_s) = \frac{\delta}{1-\delta} E\left[V(x^* + \varepsilon_{s'} - \tau_{s'}) - V(x^* + \varepsilon_{s'})\right]$$

This establishes the proof.□

Proof of Proposition III.6: Similar to that of Proposition III.1.□

Proof of Proposition III.7: Set

$$l^i(\pi_{s,t}, w_t) = -1/(1+r) W_i(\pi_{s,t}, w_t)$$
$$\tau^i(\pi_{s,t}, w_t) = \pi^i(\pi_{s,t}, w_t) - l^i(\pi_{s,t}, w_t)$$□

Proof of Proposition III.8: Apply Le Chatelier principle as in Proposition III.6.□

Proof of Proposition III.9: Equation (14) is a restricted version of equation (15). Apply Le Chatelier principle as in proposition 6.□

Proof of Proposition IV.1:

To see why Part (1) holds, let $V_{00}(x)$ denote the agent's value function if the investment were not allowed. *Ex ante,* having the option to invest cannot make the agent worse off than $V_{00}(x)$. The agent's expected utility if she were to invest today is $V_0^1(x)$ which, by construction, is equal to $V_1(x-k)$. We have shown that the agent cannot or does not want to borrow. Consequently, for $x < k$, $V_1(x-k)$ is not defined or $-\infty$. If the investment is profitable enough, $V_1(x-k)$ must eventually cross $V_{00}(x)$. These concepts are illustrated in Figure IV.5.

Suppose that the agent was made a once and for all offer to invest today. $V_1(x-k)$ is the value of using the option; $V_{00}(x)$ is the value of not investing. If $V_1(x-k)$ and $V_{00}(x)$ cross, say at x^*, then the agent invests if $x > x^*$ and does not invest if $x < x^*$. Now suppose that the agent can invest either today or tomorrow. If she invests today, she gets the same utility from investment $V_1(x-k)$ as before. Suppose she decides to wait and chooses an optimal level of W_{t+1}, given that she will have the option to invest tomorrow. Let the value of that choice be denoted $\bar{V}_0^0(x)$. Since she still has the option to invest tomorrow, the utility she will get from a given level of cash on hand x tomorrow is the *Sup* of $V_{00}(x)$ and $V_1(x-k)$. Denote that utility $\bar{V}_0$. Clearly $E\bar{V}_0$ is larger than EV_{00}. By equation (3), it therefore must be that

$\bar{V}_0^0(x) \geq V_{00}(x)$ for all x: tomorrow's option to invest raises the agent's utility.

Prolonging the time during which the agent may decide to invest can only further increase her *ex ante* utility. To see why, suppose the agent is given three periods during which investment is possible. Consider the first period. Her payoff if she invests immediately is unchanged; it is $V_t(x-k)$. If she waits, her utility tomorrow is:

$$\bar{\bar{V}}_0(x) = Max\ \{\bar{V}_0^0(x),\ V_1(x-k)\}$$

It is clear that $\bar{\bar{V}}_0(x) \geq \bar{V}_0(x)$ which was itself $\geq V_{00}(x)$. We can thus apply the same argument as before: by equation (114), the utility of waiting has increased further. Applying the same logic recursively, it is clear that the option to invest raises the agent's utility above $V_{00}(x)$ even when the investment is not undertaken. It cannot, however, raise the agent's utility above what it would get by investing immediately.

Part (2) immediately follows from the following argument. Consider an agent who can invest either today or tomorrow. In the proof of proposition 1, we saw that $\bar{V}_0^0(x) \geq V_{00}(x)$. This means that $\bar{V}_0^0(x)$ cuts $V_1(x-k)$ above x^* -- say at x^{**}. There is therefore a range of values of cash on hand for which an agent without the option to wait would invest while an agent who can wait would prefer to (see also Figure IV.5). By the proof of proposition 1, $V_0^0(x)$ can only be raised further when more options are added. Adding options can therefore only increase the range of cash on hand values over which it is preferable to wait.□

Proof of Proposition IV.1:

Let $V_{00}(.)$ be, as before, the value function when the investment is not allowed. For $x = 0$, $V_1(x-k)$ is $-\infty$. Given (A2), for $x \to \infty$, $V_1(x-k)$ and $V_{00}(x)$ are approximately linear. Therefore, by (A1), $V_1(x-k)$ is then greater than $V_{00}(x)$. Given that instantaneous utility is continuous and concave, both V_1 and V_{00} are continuous (and concave). Then they must intersect at least once. Using the same backward induction argument used in proposition IV.1, it is possible to show that $V_1(x-k)$ and $V_0^0(x)$ must also intersect. This proves the first part. If they intersect only once, say at x^*, then $V_1(x-k) > V_0^0(x)$ for all $x > x^*$ and vice versa for all $x < x^*$. This proves the second part. The last part follows because, as was shown above, for a large enough x $V_1(x-k) > V_0^0(x)$, and vice versa for a low enough x.□

Figure III.1. Risk-sharing and impatience

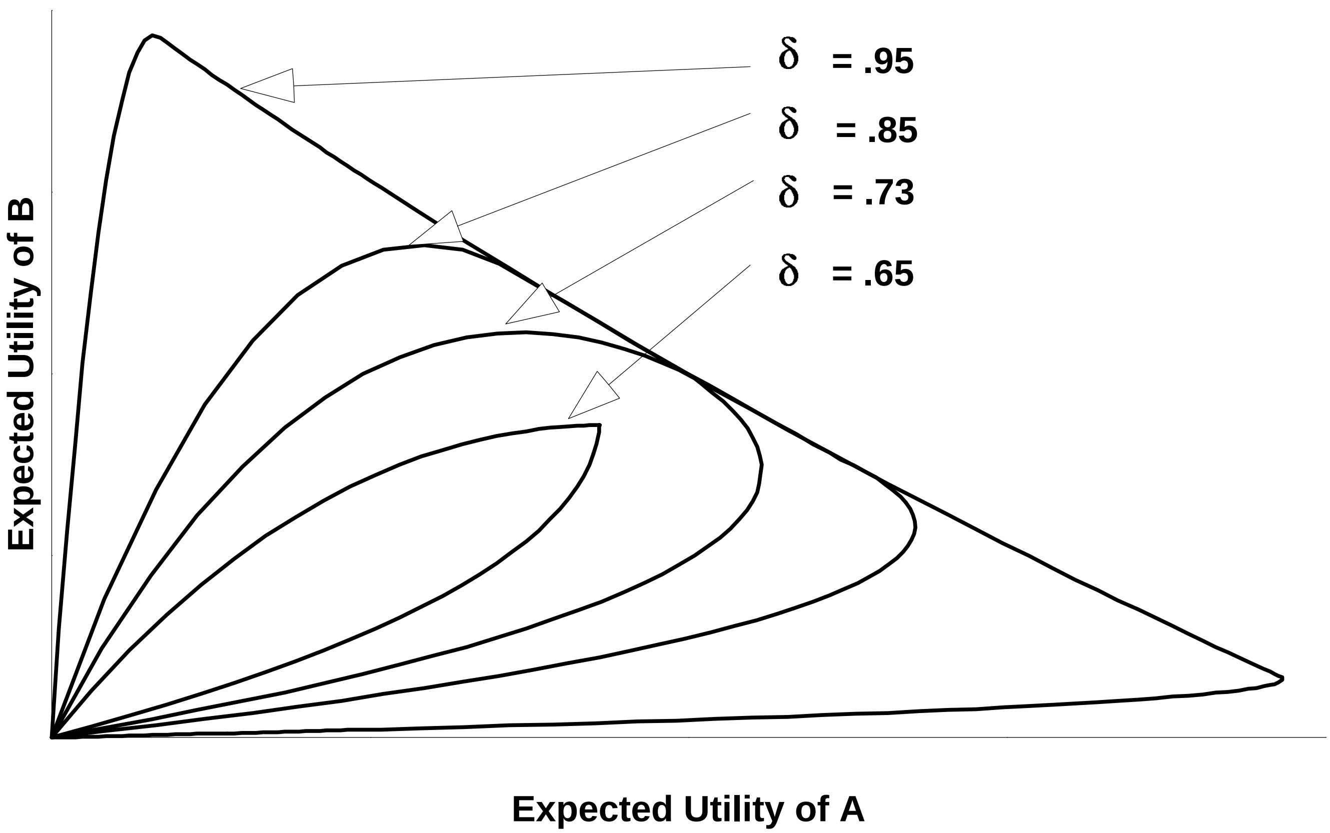


Figure III.2. Renegotiation-proof equilibria

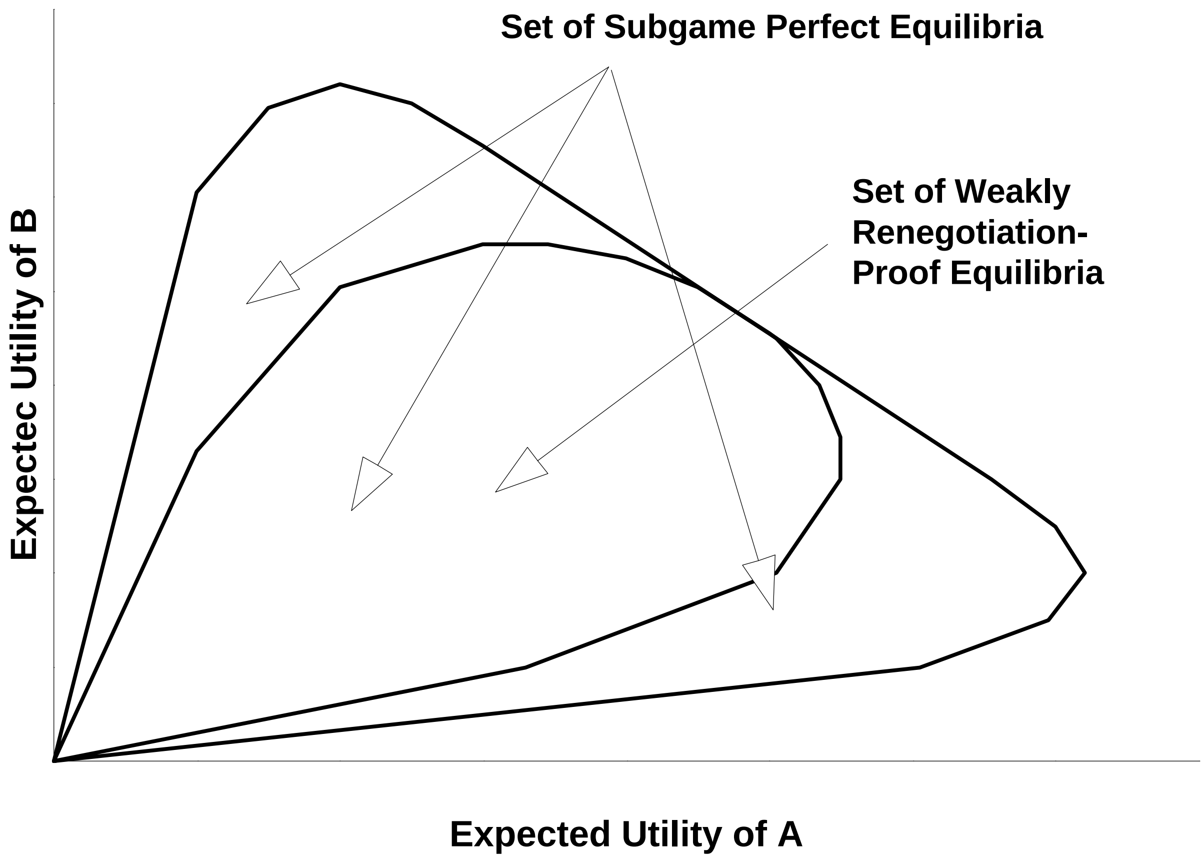


Figure III.3. Coalition-proof equilibria

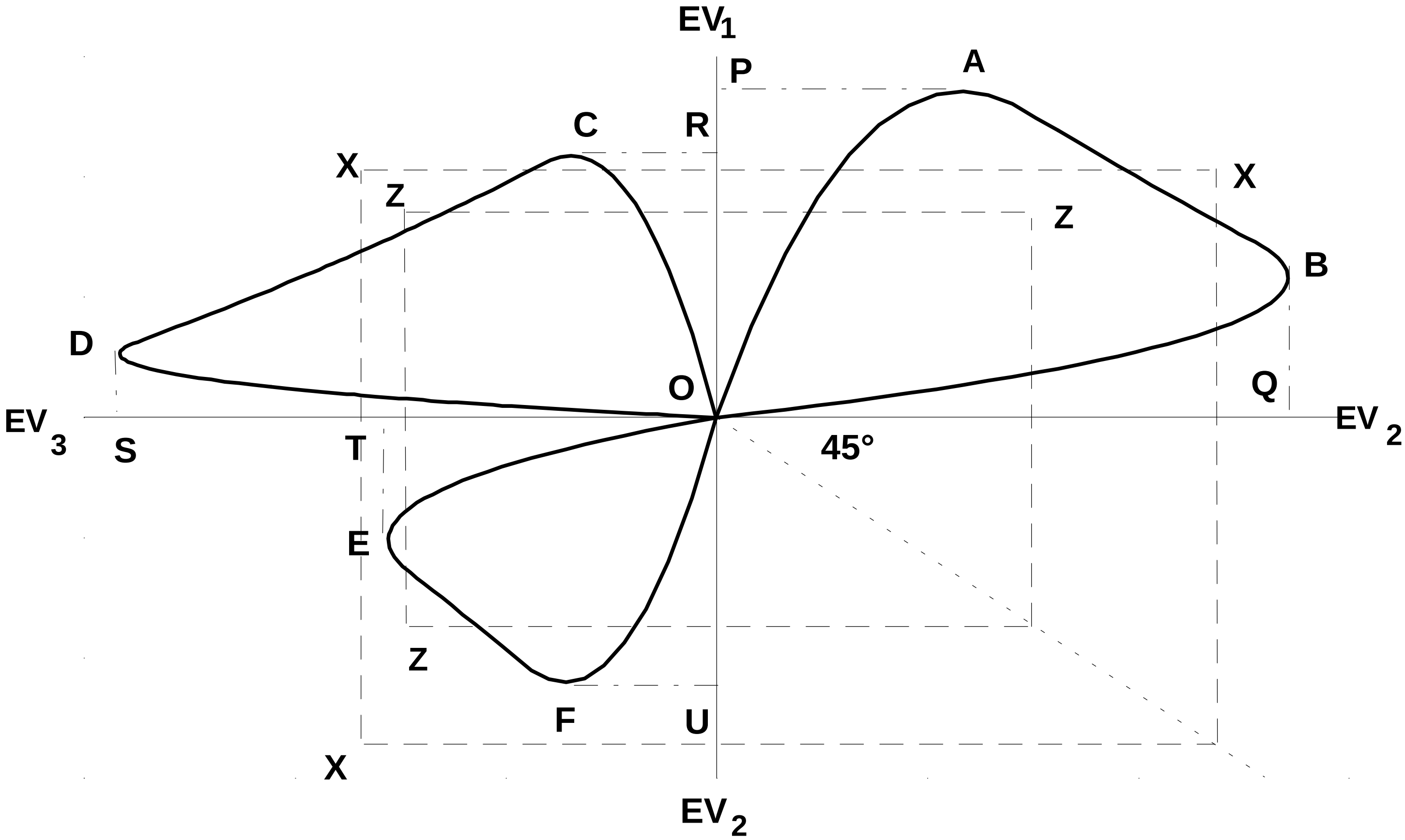


Figure III.4. Coalitions and asymmetry

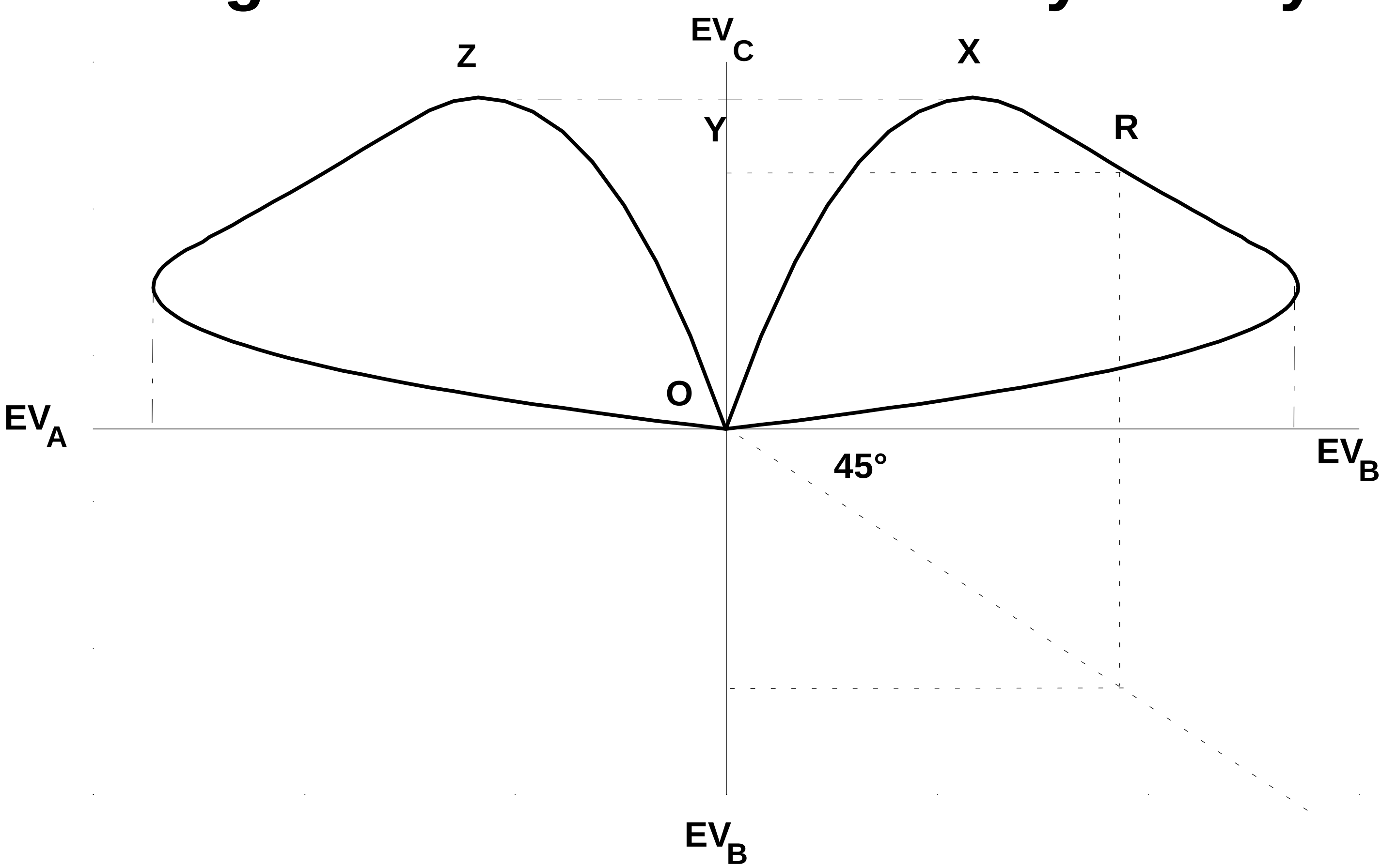


Figure IV.1. Effect of the variance of the food price

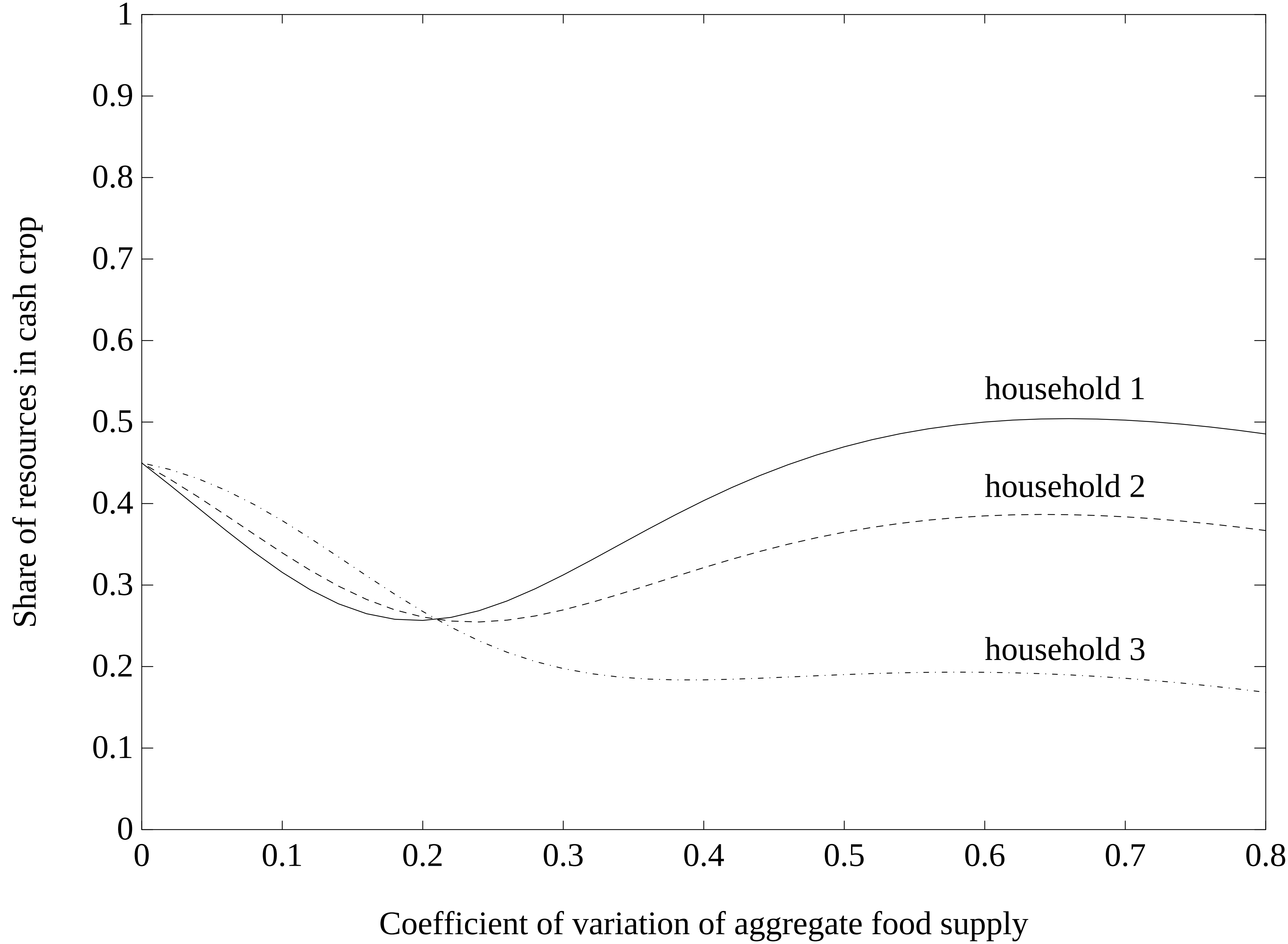


Figure IV.2. Effect of the market price elasticity of the cash crop

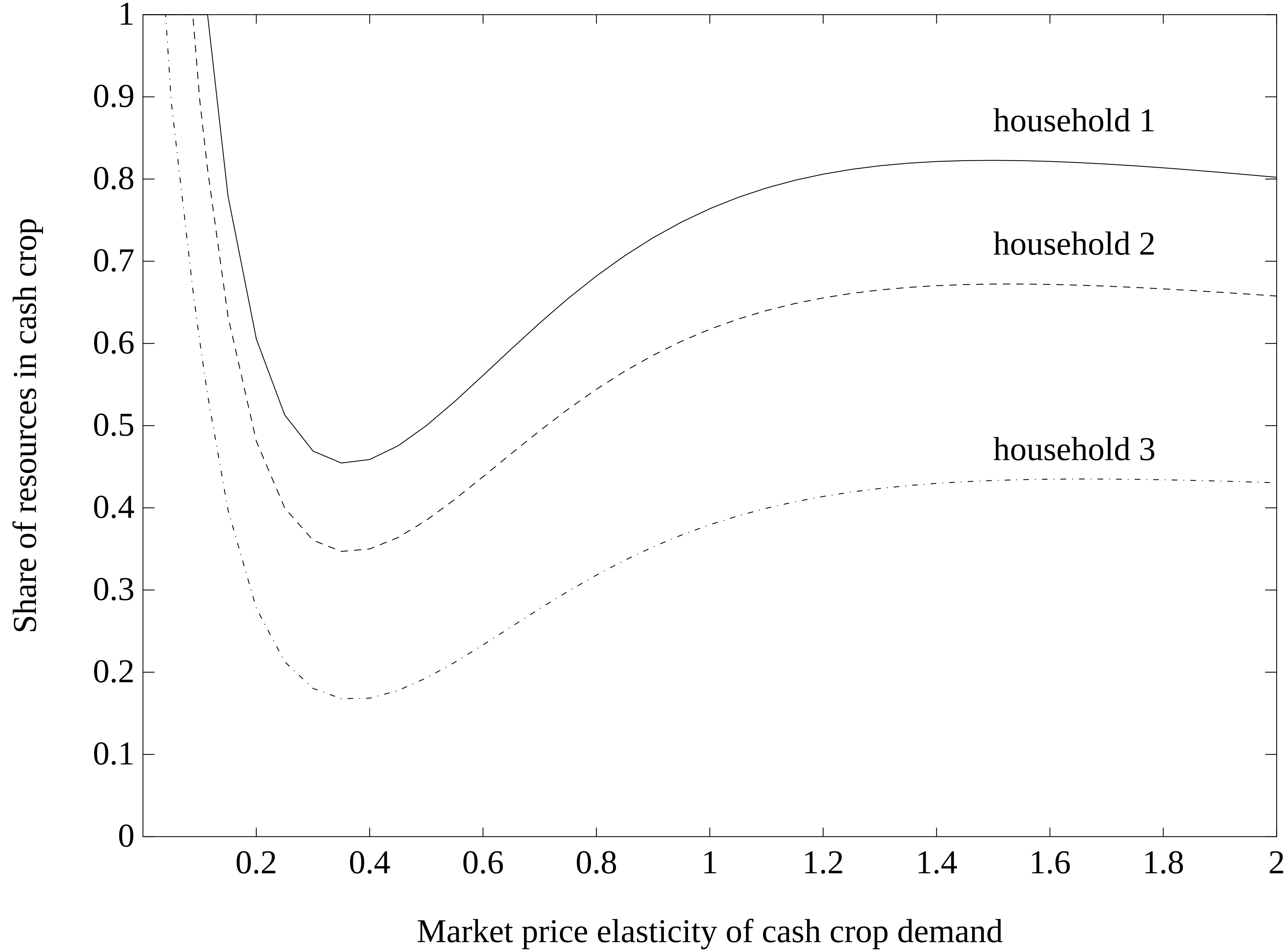


Figure IV.3. Effect of the market price elasticity of the food crop

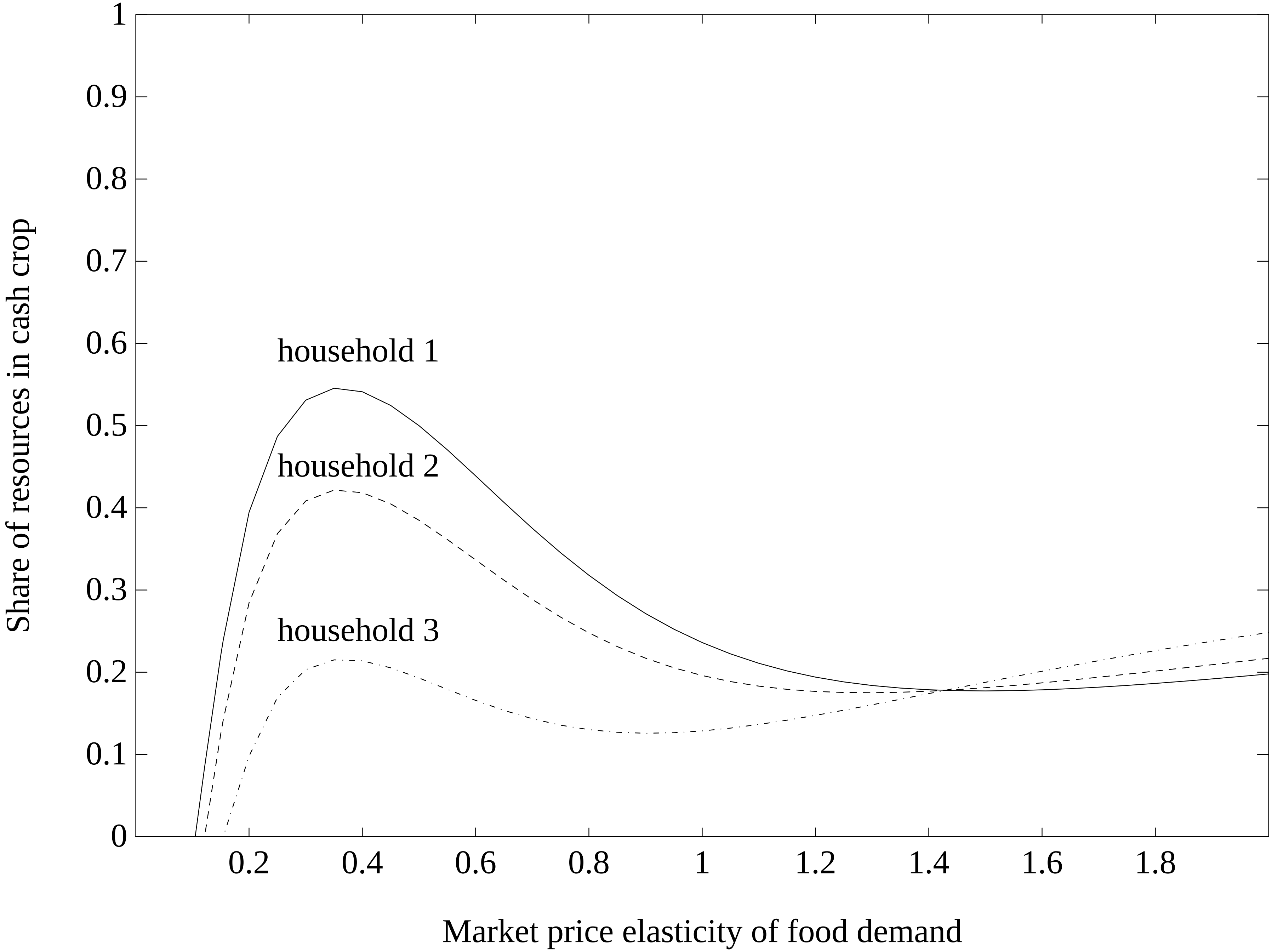


Figure IV.4. Effect of the correlation between crop revenues

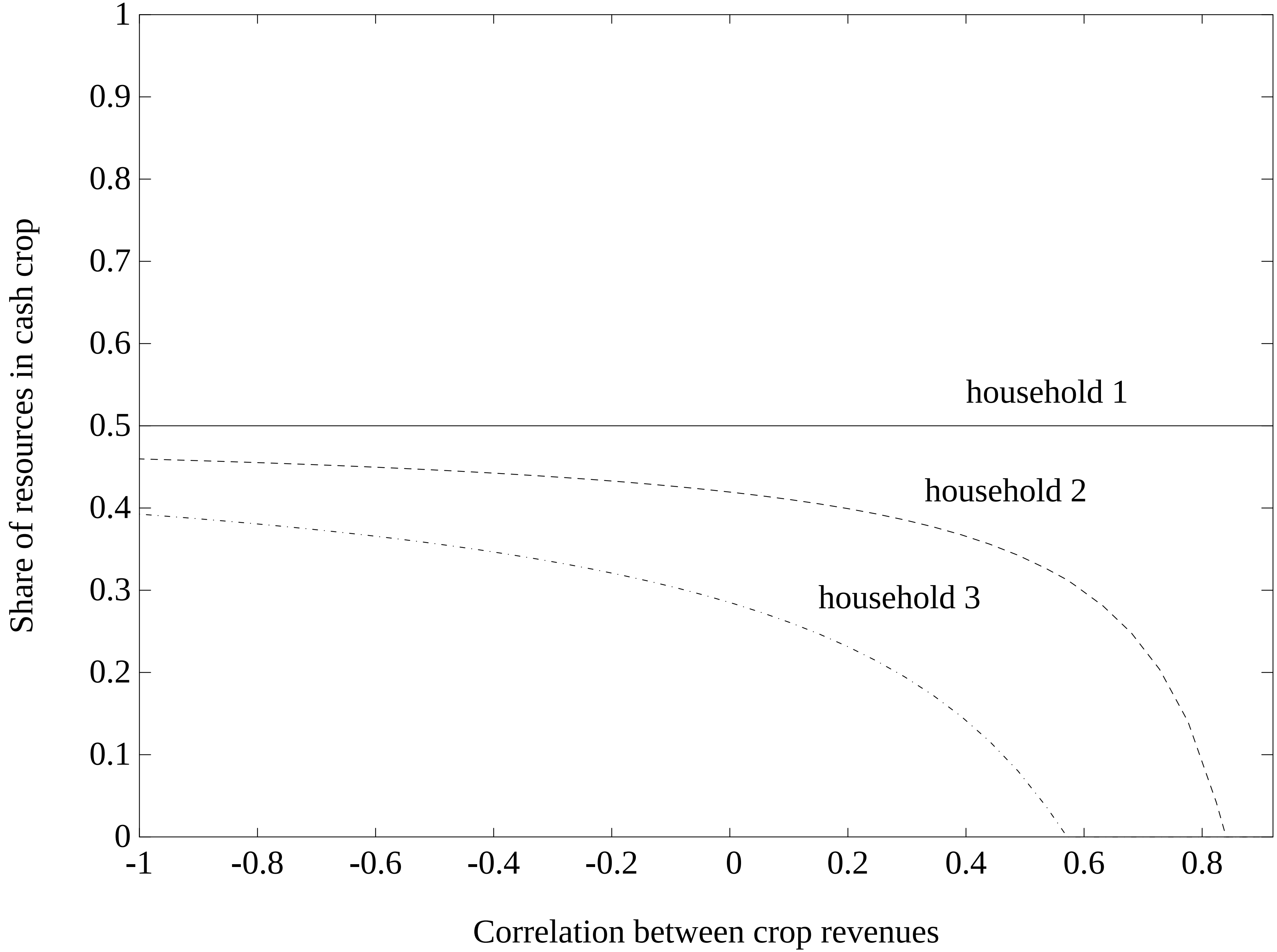
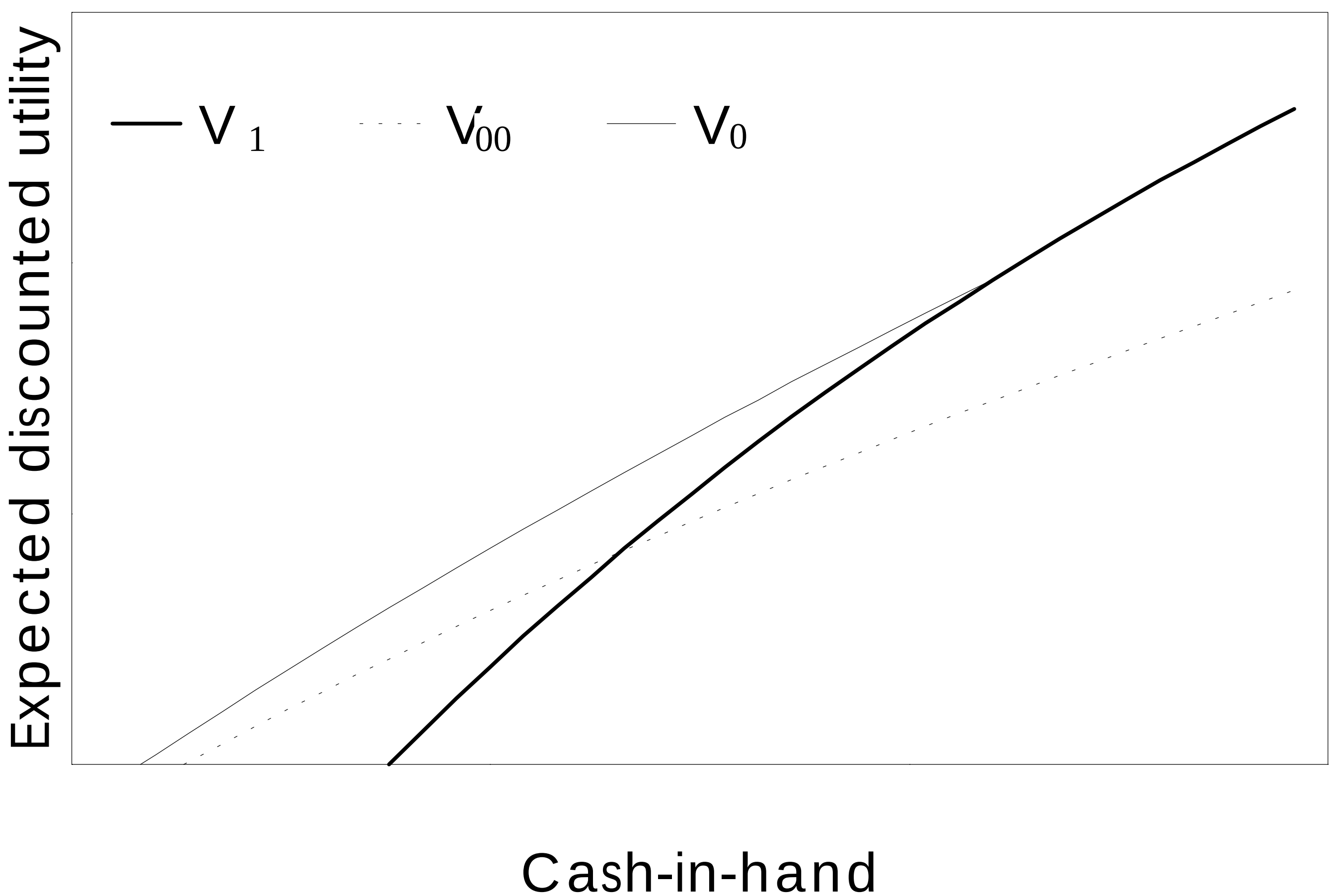


Figure IV.5. Value of Investment Option



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