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VOTING OVER INFORMAL RISK-SHARING RULES

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Abstract

People vote over risk-sharing rules to cope with random revenues. Risk-sharing rules are enforced through peer pressure: those who comply exert a negative externality on those who do not. People are differently affected by this externality. I determine the elected risk-sharing rules and the level of compliance. It turns out that full risk-sharing is achieved only if everybody comply. Partial risk-sharing is more often achieved with, sometime, some level of non-compliance. In many cases, a majority of people votes over and complies with the risk-sharing rule that maximizes their own expected payoff.

Key words: risk sharing, mutual insurance, enforcement, peer-pressure, political economy.
JEL classification: H21, O15, O17.

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1 Introduction

High income fluctuations is part of life in developing countries. To cope with a risky environment, households have developed risk-sharing strategies, including mutual assistance, credit with contingent repayments, or simply private transfers within extended families, lineage or kinship groups (Fafchamps 1992, Udry, 1994, Besley, 1995, Fafchamps, 2003, Dercon 2004). Most of those strategies are informal in the sense that they are not legally enforceable. They somehow respond to the lack of formal risk-sharing devices, such as private insurance, credit, welfare-state benefits, health insurance, income redistribution.

In a risky world populated by risk-averse agents, sharing risk is individually efficient. People would certainly agree with any rule that increase their welfare by sharing risk among them. But risk-sharing generally entails some from of income redistribution from the most successful persons to the less successful ones. Once people are endowed with permanent high income flows, they might be reluctant to transfer part of their income. They would certainly refuse to follow what the risk-sharing rule prescribes (i.e. to share their income), even if they previously (i.e. before becoming rich) adhered to this rule. This raises the issue of the enforcement of such risk-sharing rules in economies without legal enforcement systems.

This paper address the issue of the design and enforcement of informal risk-sharing rules. It models the design of risk-sharing rules as a collective choice through majority voting. People vote behind a veil of ignorance over future income. This paper also posits an enforcement mechanism based on social pressure. People decide to comply or not with the risk-sharing arrangement once they know their income. Those who comply exert a negative externality on others. Those who do not comply incur an utility loss proportional to the level of compliance. This externality affects people differently. Some people are thus more inclined to comply than others.

Such an enforcement mechanism is limited in the sense it is sometime impossible or, at least too costly, to make everybody comply with a rule. People are awarded of this enforcement problem when they design risk-sharing rules. Consequently, unlike in a world with perfect enforcement, full risk-sharing might not be implementable or even desirable. It is indeed achieved only if such a rule is fulfilled by everybody. Otherwise, and more likely, partial risk-sharing is achieved. In particular, the model often leads to a political equilibrium where a majority of people votes for and then complies with the risk-sharing rule that maximizes their own expected payoff.

The paper proceeds as follow. Section 2 motivates the main assumptions and relates the paper with the literature. Section 3 presents the model. Section 4 analyzes the enforcement or compliance problem in a non-cooperative game. Section 5 endogenizes the risk-sharing rule in a voting game. Section 6 examines the individual's incentives to increase personal wealth when people enforce a risk-sharing rule. Section 7 concludes with two remarks.

2 Motivation and related literature

So far, the design and enforcement of risk-sharing arrangements has been analyzed in repeated relationships (e.g. Coate and Ravallion, 1993, Ligon, Thomas and Worral, 1997, Genicot and Ray, 2003, Bloch, Genicot and Ray, 2004, Dubois, Jullien and Magnac, 2005). These papers have formalized the idea that people are motivated by reciprocity when they perform private transfers: A rich person agrees to share his higher income because he expects to be paid back when he is on need. Formally speaking, in these papers, informal risk-sharing arrangements emerge as self-enforcing contracts among risk-averse agents facing random shocks in a repeated game.[1]

Undoubtedly, reciprocity plays a rule in motivating the emergence and perenniality of risk-sharing arrangements in developing countries. However, it fails to explain why people with high and secure income levels subsidize poor relatives with limited future opportunities. For example, Lucas and Stark (1985) observed that migrants remit part of their revenue to their family even if they do not expect to be paid back. Fafchamps (1995) points out that people suffering from incurable diseases, and physical or mental handicap, are not excluded from the mutual assistance network. Fafchamps (2003) also questions the support to old people who are likely to be net recipient of assistance and, due to short like expectancy, have not much time left to reciprocate. He argues that, in order to obtain this support, old people have granted

[1] I should add that the literature also pointed out altruism as a motive for informal risk-sharing (see e.g. Dearden and Ravallion, 1988).

a lot of political and economic power in pre-industrial society. They are thus armed to exert pressure and social sanctions to younger people.

More importantly, the repeated game approach ignores the influence of communities (families, villages, kinships,...) on individual's behavior. It postulates that people enter into risk-sharing agreements on an individual basis in an economic environment free of any obligation, customary law or social norm. In contrast, anthropologists emphasize the role of the community (the extended family, lineage or kinship group) in the behavior of individuals within traditional societies, especially regarding redistribution and mutual assistance (see Platteau, 2000, Fafchamps, 2003). They argue that unwritten rules and behavioral codes do exist in these communities. When people make choices, they take into account how their behavior will be perceived by the members of their group. Thus, a person's behavior should be analyzed in conjunction with his community. I briefly illustrate this point with two anthropological studies.

The first one, "Kwanim Pa", by Wendy James (1979), analyzes the behavior of the Uduk, an ethnic group of cultivating people located in the Sudan-Ethiopian borderlands. The author argues that strong sharing obligations within the so-called birth-group based on principles of equality do exist in the Uduk society. She writes:

"Between persons, there are conventional expectations of cooperation and sharing in terms of which the Uduk judge individual behavior."

This means that not only agricultural production must be shared, but also the work must be fairly distributed within the community. James argues that man is duty-bound not only to cultivate fields for himself and his immediate dependants, but also to assist in the cultivation of other men's fields, especially those of his immediate birth-group. To avoid public disapproval, he must be careful not to work too hard on his own fields at the expense of others. If his fields appear to do surprisingly well, he will be criticized to the same extent as if he has shirked his duty. He will be perceived as having invested far more effort in his own fields, than on the land of others, for the purpose of self-enrichment.[2] Not surprising, amassing wealth

[2] James reported that a man sabotaged his own successful new plants because he was afraid people might think he was trying to get rich!

without sharing, is disapproved in Uduk communities as in many others traditional society (see Platteau, 1996 for further evidence).[3]

The second ethnographic work, "Palms, Wine, and Witnesses" by David J. Parkin (1972), about in the Giriama of Southern Kenya, highlights the importance of redistribution in a society relying on customary law. The Giriama's economy is based on palm trees which requires long term investment and, therefore, secure property rights. Parkin argues that it involves a "redistributional economy", in which wealth is mainly invested in the "purchase" of people for support on matters such as such as the ownership of land, palm trees, moveable inherited wealth, or bridewealth.[4]

The anthropological literature suggests two levels of decision-making in traditional societies: The community level and the individual level. The community designs rules that must be followed by its members. People are governed by these informal rules which are enforced through social pressure: Those who deviate suffer from public disapproval and social sanctions.[5]

Accordingly, in this paper, risk-sharing is an informal rule designed democratically by the community members.[6] Then each member individually decides to comply or not with the elected risk-sharing rule. People suffer from social pressure and/or sanctions if they do not comply. This translates formally in the model into an utility loss which is proportional to the level of compliance within the community.

This paper is not the first to model the cost of deviating from social norms as an utility loss. In his theory of social customs, Akerlof (1980) assumes that person's utility include his reputation within the community he or she belongs. As in the present paper, deviating from social customs imply a loss of reputation proportional to the level of norm obedience. The

[3]For the Uduk, the sole way to save is to convert crop surplus into animal wealth. This is precisely because animals are jointly owned by birth-group members.

[4]In addition, since palm wine cannot be preserved more than a couple of days, it cannot be stored until periods of scarcity (as precautionary saving). Any surplus is thus spread out in the kinship neighborhood through a system of redistributional obligation.

[5]In a more general perspective, notice that this approach is consistent with Elster (1989)'s view that social norms include a penalty to sanction disobedience.

[6]It is modeled as a direct voting process.

idea of including the opinion of others as a commodity into one agent utility function goes back, at least, to Becker (1974). In labor economics, Kandel and Lazear (1992) have modeled peer pressure on work norms in a similar way.

This utility loss from deviating from informal rules (such as solidarity obligation) has several interpretations. First of all, it captures personal's feelings such a guilt or shame.[7] As argued in Elster (1998), these feelings can be modeled as utility losses that depend on the morality of other agents in regard to the code of behavior. The larger the percentage of the population adhering to this code, the more intensely it is felt by the individual. This formalization in consistent with experimental evidences that people's behaviors are judged, reward or sanctioned by peers (see Gächter and Fehr, 1999, or Barr, 2001).[8]

Secondly, it might also model a pecuniary sanction such as exclusion from resources controlled by the community (e.g. land as in Parkin, 1972, common-pool resources such as forest, fishery, water, inheritance as in Hoddinott, 1994) or others punishment from any form of informal justice (e.g. witchcraft).[9] These sanctions are more likely to be applied and to be costly as more people follow the rule. Therefore, the more people fulfill the rule, the higher is the expected penalty for those who deviate.

The paper is related to the literature on the political economy of unemployment insurance. It shares several features with Lindbeck, Nyberg and Weibull (1999)'s paper in which people vote over redistribution schemes from the workers to the jobless in an economy where living off one's own work is a social norm. They introduce a similar utility loss proportional to the adherence to the working social norm which affects those who live on welfare. However, Lindbeck and al. (1999) focus on redistribution with an exogenous working norm with legal enforcement (at no cost), whereas I endogenize a risk-sharing rule with peer pressure as a

[7]This may explain why a large part of private transfers are performed during social event and ceremonies (e.g. funerals in Parkin, 1972), i.e. when people's behavior regarding gifts are observable by the whole community.

[8]In Harsanyi's words *"People's behavior can largely be explained in terms of two dominant interests: economic gain and social acceptance"* John Harsanyi (1969) (cited by Gächter and Fehr, 1999).

[9]According to Platteau (1996) sorcery or witchcraft serves as a form of social justice in many traditional societies. Also Parkin (1972) notices that *"the assumption seems to be widespread in Africa that economically successful persons are likely to suffer the sorcery or witchcraft of those who feel relatively deprived."* Consistently to the model, people might differ on their vulnerability to sorcery.

device to enforce redistribution. Here, people vote within an uncertain world behind a veil of ignorance over their future income. In contrast, in Lindbeck and al. (1999), people perfectly foresight their own income when they vote. As a consequence, people are less prone to redistribution: If workers constitute a majority, the unique political equilibrium prescribes no income redistribution at all.[10] In contrast, here, the political equilibrium entails some redistribution even with a majority of tax payers.

In Wright (1986), people vote on an unemployment insurance policy knowing their current employment status but under uncertainty on their future status. The elected unemployment insurance policy maximizes the expected utility of current employed voters because their constitute a majority of voters. Since their are currently tax payers, they prefer uncomplete insurance. Wright does not address the issue of enforcement. His partial insurance result is due to the predominance of tax payers and not on enforcement problems. I now introduce the model.

3 The model

A community is composed of a continuum of individuals of measure 1. Agents have quasi-linear preferences on consumption C and peer disapproval or social sanction S represented by the utility function $u(C) - \theta S$. The function u is assumed increasing and strictly concave ($u' > 0$ and $u'' < 0$). All agents are thus equally risk averse but they are differently affected by peer disapproval/social sanction S. The parameter θ represents individual's taste for social sanction: Agents with a higher (lower) θ are more (less) hurt by the same sanction S. It is private information distributed in $\Theta = [\underline{\theta}, \bar{\theta}]$ according to a publicly known density function f. The cumulative is denoted F. The function f is strictly positive and twice continuously differentiable on Θ. A person endowed with a utility parameter θ will be referred as a θ-person or a person of type θ.

Each agent produces a random income which is high $\bar{y}$ with probability p and low $\underline{y}$ with probability $1-p$, with $\bar{y} > \underline{y}$. Agents face independent and identical probability distributions. An agent who receives $\bar{y}$ ($\underline{y}$), henceforth qualified as "successful" or "rich"("unsuccessful" or

[10] They introduce altruism to produce some income redistribution emerges with a majority of workers.

"poor").

A risk-sharing rule is a vector $(t, r) \in \mathbb{R}^+ \times \mathbb{R}^+$. t is the tax paid by a successful/rich person while r is the subsidy received by a unsuccessful/poor person. It forces a rich person to consume only $\bar{y} - t$ and allows a poor person to consume $\underline{y} - r$. A risk-sharing rule must be budget balanced in the sense that what is given to the poor must be entirely financed by what is collected within the rich population share. However, some rich might not comply with the rule, i.e., not pay the tax t. We therefore denote μ the proportion of compliance to the rule *within the rich population* (with $1 \leq \mu \leq 1$). Since the $1 - p$ poor receive r and a share μ of the p rich pay t, the budget balance constraint writes,

$$p\mu t = (1 - p)r$$

Each compliant person assigns a fix loss of utility $s > 0$ to a non-compliant person. Since the $1 - p$ poor and a share μ of the p rich comply, the total cost incurred from non-complying is $S = (1 - p + \mu p)s$.

In the above framework, people make two choices. First, they vote over risk-sharing rules. Second, they individually decide wether to comply or not with the elected rule which means paying the tax t if they are rich.[11] The design of a risk-sharing rule is a collective choice selected *ex ante*, i.e. before observing income, or under a "veil of ignorance".[12] The compliance strategy is an individual choice undertaken non-cooperatively *ex post*, i.e. after observing income. It leads to Nash equilibria level of compliance to the elected rule. In what follows, we proceed by backward induction: We first analyze the second choice (i.e. compliance to a given risk-sharing rule, Section 4) before turning to the first choice (vote for a risk-sharing rule, Section 5).

4 Compliance with a risk-sharing rule

In this section, we find out the Nash equilibria of the compliance non-cooperative game.

[11] A poor would obviously comply with a rule that provides more consumption.

[12] To be precise, the veil of ignorance is on income but not on references since each agent knows her θ when she votes. It is not a veil of ignorance on income opportunities because the probability p is perfectly forecasted and homogeneous.

First, consider a poor person. Of course, it is in his self-interest to comply: his consumption is increased and he does not suffer from any social disapproval. Therefore, all poor individuals comply, thereby enjoying an utility of $u(\underline{y}+r)$.

Second, consider a rich person of type θ. If he complies, he consumes only $\bar{y}-t$ but does not suffer from any social sanction, thereby enjoying a utility level $u(\bar{y}-t)$. If he does not, he consumes all his revenue $\bar{y}$ but suffers from public disapproval. The social pressure exerted by the $1-p$ poor who comply and μ of the p rich who comply yields an utility loss $(1-p+p\mu)s$. The agent of type θ's utility is thus $u(\bar{y})-\theta(1-p+p\mu)s$. For a given proportion of compliant rich μ, the rich θ-person decides to comply if:

$$u(\bar{y}-t) \geq u(\bar{y})-\theta(1-p+p\mu)s,$$

that is,

$$\theta \geq \frac{u(\bar{y})-u(\bar{y}-t)}{(1-p+p\mu)s}.$$

To properly characterize the critical taste $\tilde{\theta}$ which divides the rich population among those who comply (those of type $\theta \geq \tilde{\theta}$), and those who do not (those of type $\theta < \tilde{\theta}$), we need new notation. Let $\bar{\mu}$ denote the minimum proportion of an compliant rich that convinces an agent of type $\theta = \bar{\theta}$ to comply, formally:

$$u(\bar{y}-t) = u(\bar{y})-\bar{\theta}(1-p+p\bar{\mu})s.$$

I assume that the sanction imposed by the poor share of the population alone does not induce the rich of higher type $\bar{\theta}$ to comply, i.e., $\bar{\mu} > 0$. Let $\underline{\mu}$ denote the minimum level of compliance within the rich population that convinces agent $\theta = \underline{\theta}$ to comply. It is defined by:

$$u(\bar{y}-t) = u(\bar{y})-\underline{\theta}(1-p+p\underline{\mu})s.$$

Hence, $\bar{\mu}$ and $\underline{\mu}$ are respectively defined by $\bar{\mu} = \frac{u(\bar{y})-u(\bar{y}-t)}{\bar{\theta}ps} - \frac{1-p}{p}$, and $\underline{\mu} = \frac{u(\bar{y})-u(\bar{y}-t)}{\underline{\theta}ps} - \frac{1-p}{p}$. Since $\bar{\theta} > \underline{\theta}$, then $\bar{\mu} < \underline{\mu}$. Notice that $\underline{\mu}$ does not exist if agent $\underline{\theta}$ does not comply when $\mu = 1$. That is, if $u(\bar{y}-t) < u(\bar{y})-\underline{\theta}s$. In this case, we set $\underline{\mu} = 0$. We will denote $\hat{s}(t) = \frac{u(\bar{y})-u(\bar{y}-t)}{\underline{\theta}}$ as the lower bound on s that could make everyone comply to a given risk-sharing rule (t, r).

The taste $\tilde{\theta}$ of the agent indifferent between complying or not with (t, r) for a given μ is given by:

$$\tilde{\theta}(\mu) = \begin{cases} \underline{\theta} & if \quad \mu > \underline{\mu} \\ \dfrac{u(\bar{y}) - u(\bar{y} - t)}{(1 - p + p\mu)s} & if \quad \underline{\mu} \geq \mu \geq \bar{\mu} \\ \bar{\theta} & if \quad \mu < \bar{\mu} \end{cases} \tag{1}$$

While expecting μ, people with $\theta \geq \tilde{\theta}(\mu)$ (respectively $\theta < \tilde{\theta}(\mu)$) comply (do not comply) with (t, r). We now set up the proportion of rich who comply for a given $\tilde{\theta}$. Since f is the density of the agents type within the rich population share, the proportion of rich of type higher than $\tilde{\theta}$ is,

$$\mu = \int_{\tilde{\theta}}^{\bar{\theta}} f(\theta) d\theta.$$

Or,

$$\mu = 1 - F(\tilde{\theta}). \tag{2}$$

The Nash equilibria level of compliance within the rich population μ^* are determined by combining equations (1) and (2). They are defined by:

$$\mu^* = 1 - F(\tilde{\theta}(\mu^*)),$$

or, more precisely,

$$\mu^* = \begin{cases} 1 & if \quad \mu^* > \underline{\mu} \\ 1 - F\left(\dfrac{u(\bar{y}) - u(\bar{y} - t)}{(1 - p + p\mu^*)s}\right) & if \quad \underline{\mu} \geq \mu^* \geq \bar{\mu} \\ 0 & if \quad \mu^* < \bar{\mu} \end{cases} \tag{3}$$

Mathematically, here, an equilibrium is a fixed point. Since the right-hand side in (3) is increasing and continuous on $[0, 1]$, there exists at least one fix point.

Figures 1 and 2 below provides two graphic illustrations in the case θ uniformly distributed in $[\underline{\theta}, \bar{\theta}]$. It represents the function $\tilde{\theta}(\mu)$ defined in (1) by the plain line and the relation (2) by the shaded line.

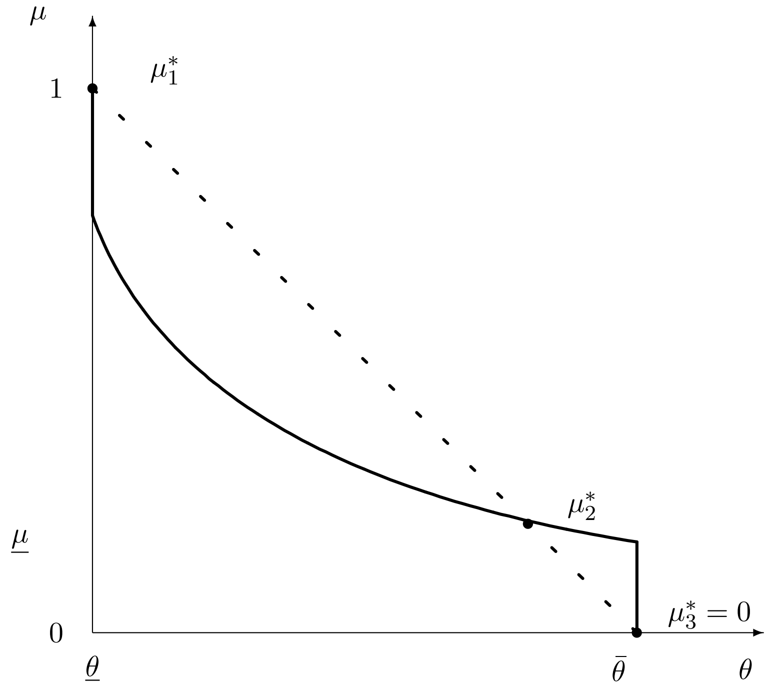

Figure 1

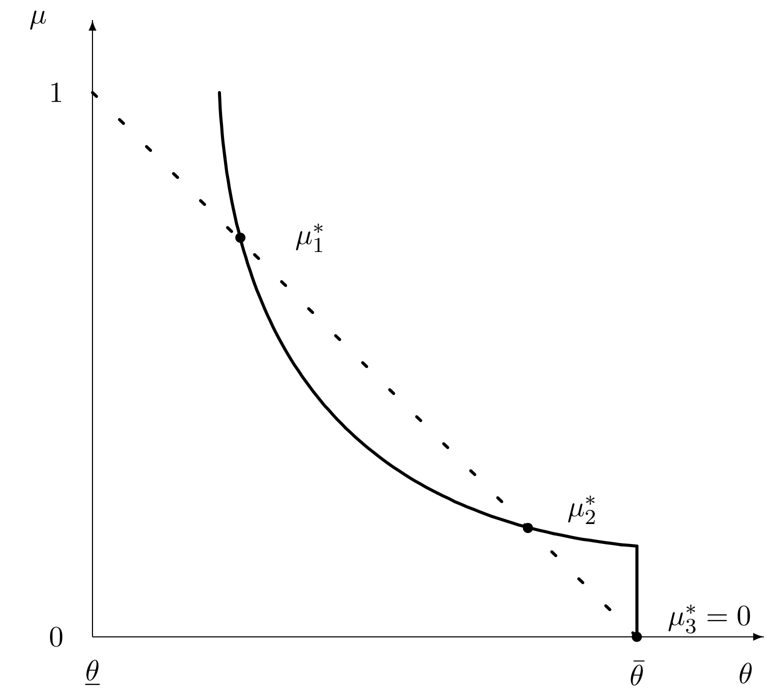

Figure 2

The equilibrium μ_3^* where none of the rich comply ($\mu_3^* = 0$) always exists. Other equilibria may exist, depending on the economic environment. There is one equilibrium μ_1^* with high compliance level (full compliance in Figure 1 and partial compliance in Figure 2) and one equilibrium μ_2^* with low compliance level. If $s \geq \hat{s}(t)$, then the peer-pressure is high enough to make everybody comply and, therefore, $\mu_1^* = 1$. Graphically, when s increases, the plain curve moves downward in Figure 2 and crosses the vertical axe when $s \geq \hat{s}(t)$. Otherwise, i.e. when $s < \hat{s}(t)$, some rich people deviate from the risk-sharing rule.

Clearly, in general, the game leads to several equilibrium levels of compliance. Multiplicity of equilibria raises the question of the equilibrium selection that I address now.

First, among this equilibria, some of them are unstable. For instance, in Figures 1, μ_2^* is unstable whereas μ_1^* and μ_3^* are stable. These unstable equilibria are unlikely to arise because there are difficult to sustain.[13] They are therefore excluded. An interior equilibrium μ^* is locally stable if it satisfies:[14]

$$1 + f(\tilde{\theta}(\mu^*))\tilde{\theta}'(\mu^*) > 0. \tag{4}$$

It implies that less people comply in equilibrium when the informal tax t increases, formally,

$$\frac{d\mu^*}{dt} = -\frac{\dfrac{u'(\bar{y} - t)}{(1 - p + p\mu^*)s}}{1 + f(\tilde{\theta}(\mu^*))\tilde{\theta}'(\mu^*)} < 0. \tag{5}$$

Second, the risk-sharing rule itself coordinates people's expectation on an unique level of compliance through the budget balance. Indeed, knowing the level of per-capita tax t and subsidy r, people can perfectly foresight the unique stable equilibrium level of compliance that balances the risk-sharing rule. Formally, they compute μ^* that satisfies:

$$p\mu^* t = (1 - p)r. \tag{6}$$

[13]Indeed, a deviation from a (positive measured) subset of agents from μ_2^* leads to either μ_1^* and μ_3^* when people readjust their expectations following a tâtonnement process. Consider, for instance, a deviation from the out-of-equilibrium level of compliance $\mu' \neq \mu_2^*$. Assume that, staring from the expected level of compliance μ', people play their best reply until they reach the next Nash equilibrium. Then μ_3^* or μ_1^* would be reached, not μ_2^*.

[14]$\tilde{\theta}'$ denotes the first derivative of the function $\tilde{\theta}$. Notice that the interior stable equilibrium is unique if the proportion of type θ agents is not decreasing with θ.

When deciding to comply or not, a rich person expects the level of compliance to satisfy (6). Doing so, she selects a single equilibrium among the set of equilibria. Moreover, in the voting process, people only consider the risk-sharing rules that are budget-balanced by a stable level of compliance as potential candidates. Formally, they vote only on the risk-sharing rules (t, r) for which there exists a level of compliance μ^* that satisfies equations (3), (4) and (6). I now turn to the voting process.

5 Political equilibria

A rule (t, r) such that there exists an equilibrium level of compliance μ^* that satisfies (3), (4) and (6) will be referred as a *feasible* risk-sharing rule. The set of such risk-sharing policies is denoted Φ.[15] Risk-sharing rules must be feasible to be candidate.

When deciding to vote for or against a feasible risk-sharing rule $(t, r) \in \Phi$, an arbitrary agent of type θ computes his expected payoff if he complies,

$$U_c(t, r) = pu(\bar{y} - t) + (1 - p)u(\underline{y} + r), \tag{7}$$

as well as his expected payoff if he does not,

$$U_n(t, r, \theta) = p\{u(\bar{y}) - \theta(1 - p + \mu^* p)s\} + (1 - p)u(\underline{y} + r), \tag{8}$$

where μ^* is defined by (3) and (6), and satisfies (4).

Anticipating her future compliance choice, a person's expected payoff with the risk-sharing policy (t, r) is the maximal value of (7) and (8), formally,

$$U(t, r, \theta) = \max\{U_c(t, r), U_n(t, r, \theta)\}.$$

A person prefers $(t, r) \in \Phi$ to $(t', r') \in \Phi$ if and only if $U(t, r, \theta) \geq U(t', r', \theta)$.

In this section, I first establish some general results on a class of political equilibria. Second, I illustrate those equilibria and discuss other equilibria with an example. Third, I examine the welfare properties of the political equilibria.

[15] It is easy to show that Φ is not empty. Indeed, if both transfers are zero, then all individuals enforce the policy which is budget balanced (at zero) and stable. This establishes that $(0, 0) \in \Phi$.

5.1 The best compliant rule as a Condorcet winner

Let introduce some specific risk-sharing rules. First, the *best compliant rule* is the risk-sharing rule that maximizes the expected utility of those who comply with it. Denoted (t^c, r^c), it solves,

$$\max_{t,r} U_c(t, r) \text{ subject to } (t, r) \in \Phi. \tag{9}$$

Second, *θ's best uncompliant rule* is the rule that maximizes a θ-person's expected utility when she does no comply. Denoted (t^θ, r^θ), it solves,

$$\max_{t,r} U_n(t, r, \theta) \text{ subject to } (t, r) \in \Phi. \tag{10}$$

Assume that the solution to (9) and (10) are unique for every θ.[16] Denote the median voter θ_m. The next proposition provides a necessary condition on the median voter's preferences that insures the election of the best compliant rule.

Proposition 1 *If* $U_c(t^c, r^c) \geq U_n(t^{\theta_m}, r^{\theta_m}, \theta_m)$ *then the best compliant risk-sharing rule* (t^c, r^c) *is a Condorcet winner and a majority of rich complies.*

(Proof are relegated to the Appendix). Figure 3 below represents people's expected payoffs when the above condition holds.

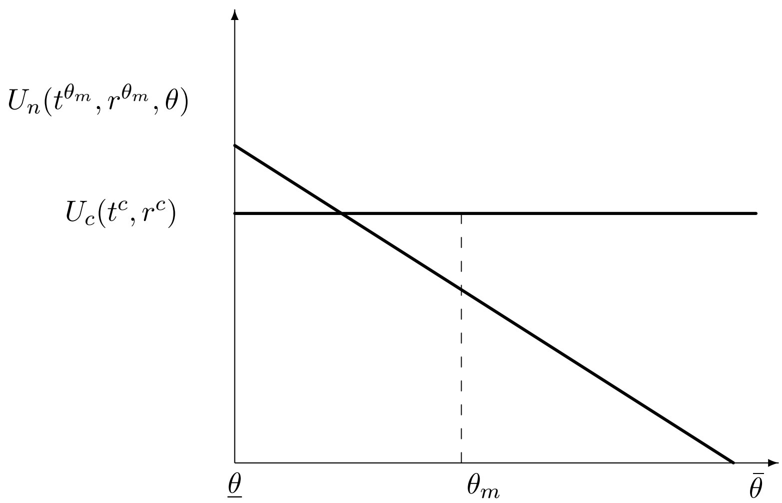

Figure 3

[16] For instance, assume that $f'(\theta) \geq 0$ for every $\theta \in \Theta$.

The plain lines represents individual's expected payoffs for every θ. The horizontal line represents people's expected utility when (t^c, r^c) is elected and they comply with it, whereas the line with negative slope represents people's expected utility when $(t^{\theta_m}, r^{\theta_m})$ is elected and they do not comply with it. The starting assumption is that the median voter is better-off with the first option. In this case, the majority complies with (t^c, r^c). By definition of (t^c, r^c), those who comply cannot increase their expected payoff with another rule. For them, the only way to increase their payoff is to elect a rule they do not comply with, preferably their best uncompliant rule. But, by assumption, the median's voter uncompliant rule yields a lower expected payoff to the median voter. In addition, the θ's best uncompliant rule yields lower expected payoff to any individuals of type $\theta \geq \theta_m$ because those persons are more affected than the median voter by the social sanction. Since they constitute a majority, no rule can defeat (t^c, r^c), which is then a Condorcet winner.

To characterize more precisely the best compliant rule (t^c, r^c), I assume that f is non-decreasing, i.e., $f'(\theta) \geq 0$ for every $\theta \in \Theta$.[17] The best complaint rule is thus defined by the following first order condition:[18]

$$u'(\underline{y} + r^c) \left[\mu^* + t^c \frac{d\mu^*}{dt} \right] = u'(\bar{y} - t^c), \tag{11}$$

with $\mu^* = 1 - F\left(\dfrac{u(\bar{y}) - u(\bar{y} - t)}{(1 - p + p\mu^*)s}\right)$, $p\mu^* t^c = (1-p) r^c$ and $\dfrac{d\mu^*}{dt} \leq 0$.

First, (11) implies that if there is full compliance ($\mu^* = 1$) but full risk-sharing ($\bar{y} - t^c = \underline{y} + r^c$) is not achieved, the transfer made is the highest transfer accepted by the agent who is the least affected by social sanction (otherwise, we would have $\dfrac{d\mu^*}{dt} = 0$, therefore, full risk-sharing would be implemented). Therefore, even if everybody comply, the rule might impose only partial risk-sharing.

Second, (11) characterizes the trade-off between risk-sharing and enforcement. Remember that the goal of the informal rule is to share risk ex ante by redistributing ex post the revenue.

[17]This assumption guarantees that, after substituting for the constraints (3) and (6), the objective of program (9) is concave on t. It is made reasonable by interpreting θ as the individual's distance (physical or psychological) from the "core" of the community located at $\theta = \bar{\theta}$. It simply imposes that the proportion of community members does not increase as we move away from the core of the community.

[18]The first and second order conditions are provided in Appendix.

With fully enforceable rules, the first-best risk-sharing rules, which is the full risk-sharing rule, equalizes the individual's marginal utilities in each state of nature ("successful" or "unsuccessful"). Here, due to limited by enforcement, the risk-sharing rule equalizes the marginal utilities adjusted by the losses resulting from noncompliance. This term reflects the fact that when the transfer t is increased, the utility lost when successful does not fully compensate for the utility earned when unsuccessful. If a successful person has to give one extra unit of consumption, a unsuccessful person would only receive μ^* units for a constant level of compliance. Moreover, an increase of t makes the risk-sharing rule less attractive for the successful persons. Therefore, the equilibrium level of compliance μ^* decreases (Recalls that $\frac{d\mu^*}{dt} < 0$ for stable equilibria). Hence, the increase of the subsidy r is less than μ^*.

The empirical literature regarding informal risk-sharing has extensively tested and, in general, rejected a full sharing of (idiosyncratic) risk (e.g. Townsend, 1994, Ligon, Thomas and Worral, 2002). Corollary 1 provides conditions for the emergence of full risk-sharing.

Corollary 1 *Full compliance with the full risk-sharing rule is a necessary condition for the full risk-sharing rule to be elected. It is also a sufficient condition when* $U_c(t^c, r^c) \geq U_n(t^m, r^m, \theta_m)$.

In this model but without enforcement problems, full risk-sharing is efficient. It indeed maximizes people's expected utility when everybody comply. If everybody comply with the full risk-sharing rule, everybody would also comply with less demanding risk-sharing rules. But such rules assign lower expected payoff to anybody. Therefore people unanimously prefer the full risk-sharing rule when they all comply with this rule. Full risk-sharing would therefore be elected when everybody comply with it.

5.2 A three-type example

Assume that the heterogeneity of preferences is reduced to three values $\underline{\theta}$, θ_m, $\bar{\theta}$, with $\underline{\theta} < \theta_m < \bar{\theta}$, in respective proportion $\underline{q}$, q_m, $\bar{q}$, in the community, with $\underline{q} + q_m + \bar{q} = 1$. θ_m is still the median voter's type which implies $\underline{q} + q_m > \frac{1}{2}$ and $\bar{q} + q_m > \frac{1}{2}$. Notice that, due to the discontinuity of the density function for this three-type case, we cannot use the previous differentiation and integration techniques. Therefore, the optimality conditions previously derived will be slightly different. Nevertheless, by restricting to three types of θ, this example is simple and rich enough to convey some intuition.

First, of course, Corollary 1 still hold: Full risk-sharing is elected if (i) everybody comply with it and (ii) it is the median voter's best rule. Indeed, in this case, the best compliant rule (t^c, r^c) prescribes to share fully risk. Full risk-sharing with full compliance implies the same level of consumption for all revenues, equals to the average revenue, formally, $\bar{y} - t^c = \underline{y} + r^c = p\bar{y} + (1-p)\underline{y}$. The full risk-sharing rule is a Condorcet winner when all $\underline{\theta}$-persons comply with this rule, i.e., if $u(p\bar{y} + (1-p)\underline{y}) \geq u(\bar{y}) - \bar{\theta}s$.[19]

Second, when the above condition does not hold (i.e. some people do not comply with the full risk-sharing rule), the best compliant rule (t^c, r^c) prescribes only partial risk-sharing. It can be still with full compliance. In this case, t^c is the highest tax that makes a $\underline{\theta}$-person comply. Formally, t^c is such that $u(\bar{y} - t^c) = u(\bar{y}) - \bar{\theta}s$. It can also be with partial compliance. Since it might be too costly in term of risk-sharing to make everybody comply, people might prefer an higher tax even if they loose all $\underline{\theta}$-persons as contributors. Then only individuals of type θ_m and $\bar{\theta}$ comply with (t^c, r^c). The level of compliance within the rich population is $\mu^* = q_m + \bar{q}$. The budget balance constraint writes $(q_m + \bar{q})pt^c = (1-p)r^c$. The best compliant rule (t^c, r^c) is then defined by the following first-order condition:[20]

$$u'(\underline{y} + r^c)(q_m + \bar{q}) = u'(\bar{y} - t^c).$$

Such a rule is elected against all other feasible rules when the median voter complies with it, that is when $u(\bar{y} - t^c) \geq u(\bar{y}) - \theta_m[1 - p + p(q_m + \bar{q})]s$.

Third, when the above condition is not satisfied, then the best compliant rule is not elected.[21] The median voter's best uncompliant rule, denoted $(t^{\theta_m}, r^{\theta_m})$, might be elected. In the present example, t^{θ_m} is simply the highest tax that a $\bar{\theta}$-person is willing to pay. Formally, t^{θ_m} is such that a $\bar{\theta}$-person is indifferent between complying or not. It satisfies $u(\bar{y} - t^{\theta_m}) =$

[19] As before, it is assumed that a agent's weigh is nil in the non-cooperative compliance subgame: When deciding not to comply, an individual does not consider the simultaneous deviation of all persons of same type. Nevertheless, the model could accommodate for a simultaneous deviation of all agents of same type without changing the results qualitatively.

[20] This condition is a special case of the first-order condition (11).

[21] This corresponds to the case $U_c(t^c, r^c) < U_n(t^{\theta_m}, r^{\theta_m}, \theta_m)$ not addressed so far.

$u(\bar{y}) - \bar{\theta}[1 - p + p\bar{q}]s$. As long as $t^{\theta_m} \neq t^c$, since both tax yields same level of compliance $\bar{q}$, we have $r^{\theta_m} > r^c$. Given that both rules yield the same level of compliance and, therefore, the same social sanction S, all those who do not comply with both rules, i.e., people of type $\underline{\theta}$ and θ_m, prefer the median voter's best uncompliant rule $(t^{\theta_m}, r^{\theta_m})$ than the best compliant rule (t^c, r^c) because the subsidy is higher: $r^{\theta_m} > r^c$. Since they constitute a majority, then $(t^{\theta_m}, r^{\theta_m})$ defeats (t^c, r^c).

Yet, another rule (other than $(t^{\theta_m}, r^{\theta_m})$ or (t^c, r^c)) can be elected still when the median voter does not comply with (t^c, r^c). People of type $\underline{\theta}$ and $\bar{\theta}$ could agree to reduce the tax level at $t' < t^{\theta_m}$ in order to make the median voter comply. The elected tax level t' is then the highest tax that make the median voter be indifferent between complying or not. Formally t' is such that $u(\bar{y} - t') = u(\bar{y}) - \theta_m[1 - p + p(q_m + \bar{q})]s$. For (t', r') to be elected, the people of type $\underline{\theta}$ and $\bar{\theta}$ must constitute a majority, i.e., we must have $\bar{q} + \underline{q} > \frac{1}{2}$. Furthermore, the $\underline{\theta}$-persons should prefer (t', r') to $(t^{\theta_m}, r^{\theta_m})$, i.e., $U_n(t', r', \underline{\theta}) \geq U_n(t^{\theta_m}, r^{\theta_m}, \underline{\theta})$. For the second condition to hold, the elected rule must yields a higher subsidy $r' > r^{\theta_m}$ to compensate for a higher social sanction due to more compliance ($q_m + \bar{q}$ instead of $\bar{q}$).

To sum-up, when the best compliant rule is not elected, this example shows first that the median voter's uncompliant rule might be elected. In this case, only a minority of people complies with the elected rule. Moreover, the elected rule maximizes the expected payoff of a non-compliant person, namely the median voter. Second, a rule which prescribes a "medium" tax level $t^c < t' < t^{\theta_m}$ might also be elected. This rule is supported by a coalition which includes people with high θ who comply anyway and people with low θ who do not comply but can cope with higher disapproval due to a higher level of compliance. In this case, the median voter's favorite rule is not elected.

Clearly, the above results and example show that people have conflicting interests when they collectively choose an informal risk-sharing rule. Does that mean that some people are worse off with the elected rule? This question is examined in the next subsection.

5.3 Welfare impact of the informal risk-sharing rule

First, it is easy to see that having (t^c, r^c) elected and enforced is better than the status quo (no risk-sharing) for everybody. Indeed, when $(t^c, r^c) \neq (0,0)$,[22] then $U(t^c, r^c, \theta) \geq U_c(t^c, r^c) > U_c(0,0)$ for every $\theta \in [\underline{\theta}, \bar{\theta}]$. In words, with (t^c, r^c), everybody gets at least the expected utility level of a compliant person. Since, by definition, this person is strictly better-off with her best complaint rule than with no risk-sharing (as long as no risk-sharing is not the best compliant rule), then everybody is also strictly better-off with (t^c, r^c) than with the status quo (no risk-sharing). This leads to the following proposition.

Proposition 2 *If (t^c, r^c) is elected, then everybody benefit from informal risk-sharing.*

Proposition 2 implies that some informal risk-sharing would emerge as long as those who comply are better-off when sharing risk informally. It therefore provides a sufficient condition for the election of an informal risk-sharing rule with any voting rule (even with unanimity).

Second, when (t^c, r^c) is not elected, people comply with a rule that does not maximize their own expected utility. Rather, the rule maximizes the utility of someone who do not comply with it. Do the compliant persons are necessarily better-off with the elected risk-sharing rule than without any rule? The answer is no. The following proposition provides a condition on the level of compliance for which those who comply are worse off.

Proposition 3 *If the elected rule yields a level of compliance $\mu^* < \dfrac{u'(\bar{y})}{u'(\underline{y})}$ then those who comply do not benefit from this elected rule.*

The political equilibrium might be such that people comply with a rule that benefits only to those who do not comply with it. It happens when the level of compliance to the elected rule is very low and, of course, the best compliance rule is not elected.

In the next section, I examine the impact of the informal risk-sharing rule on the incentives to become rich.

[22] $(t^c, r^c) = (0,0)$ means that the best compliant rule prescribes no risk-sharing and then is equivalent to the status quo.

6 Informal risk-sharing and incentives to work

Suppose that after the risk-sharing rule has been elected but before earning revenues, each individual chooses how much effort to devote in trying to become rich (e.g. by working harder). Formally, people exert an unobservable[23] and costly work effort $e \in \mathbb{R}_+$, which determines the probability to become rich $p(e)$. Let assume that this function p is such as $p' > 0$, $p'' < 0$, $p'(0) = \infty$ and $p(\infty) = 1$. Each unit of effort costs one unit of utility so that the expected payoff of a compliant person with effort level e and with the risk-sharing rule (t, r) is,

$$U_c^e(t, r, e) = p(e)u(\bar{y} - t) + (1 - p(e))u(\underline{y} + r) - e, \tag{12}$$

whereas the expected payoff of a uncompliant person θ is,

$$U_n^e(t, r, e, \theta) = p(e)\left\{u(\bar{y}) - \theta\alpha s\right\} + (1 - p(e))u(\underline{y} + r) - e, \tag{13}$$

where α, the proportion of compliance in the population, depends now on people's effort choices.

Each individual θ chooses the effort level that maximizes his expected payoff as defined in (12) for the compliant persons, and in (13) for the uncompliant ones. The following first-order conditions characterize the efforts of the compliant persons e^c and the uncompliant persons of type θ denoted $e^n(\theta)$.[24]

$$p'(e^c)\left(u(\bar{y} - t) - u(\underline{y} + r)\right) = 1,$$

$$p'(e^n(\theta))\left(u(\bar{y}) - \theta\alpha s - u(\underline{y} + r)\right) = 1.$$

Each individual equalizes the marginal benefit (left-hand side) to the marginal cost (right-hand side) of one unit of effort. The marginal benefit corresponds to the marginal probability to become rich times the incremental gain from being rich. Since the uncompliant persons

[23] Non-observability guarantees that uncompliant persons are not detected through their effort choice and, thus, refused the subsidy r from the community when they become poor.

[24] Notice that, with a continuum of agents as assumed here, an agent's effort has an infinitesimal impact on α. Therefore, when choosing how much effort to devote on work, individuals do not consider the impact of their effort on the proportion of compliance to the rule. Hence, the equilibrium level of compliance is $\alpha = \int_{\underline{\theta}}^{\tilde{\theta}(\mu^*)} (1 - p(e^n(\theta)))d\theta + \int_{\tilde{\theta}}^{\bar{\theta}} (1 - p(e^c) + p(e^c)\mu^*)d\theta$, where $e^n(\theta)$ and e^c are defined below for all $\theta \in \Theta$.

have higher ex post utility than the compliant ones when they are rich but same ex post utility when they are poor, this incremental gain is higher for those who do not comply. Therefore, those who expect not to comply when getting rich work harder than those who expect to comply. Formally, since, for any $\theta < \tilde{\theta}(\mu^*)$, $u(\bar{y}) - \theta\alpha s > u(\bar{y} - t)$, then $e^n(\theta) > e^c$. This leads to the following proposition.

Proposition 4 *Those who do not comply to the risk-sharing rule when rich work harder than those who comply.*

This last result explains why too hard workers and too successful persons are disapproved in many traditional communities as mentioned in the Introduction (see also Platteau, 1996, for further evidence, and Fafchamps, 2003, page 81, for a discussion on this issue). The main argument here is that those people are suspected to plan not to fulfill the risk-sharing rule when they will become rich. Hence, risk-sharing obligations discourage the pursuit of private wealth, not only because the return of investment is lower (the standard argument), but also because it is perceived as a deliberate deviation from these obligations and, therefore, sanctioned by the community.[25]

7 Conclusion

This paper presents a political economy approach to informal risk-sharing. People share risk by redistributing ex post their income. They vote over ex post redistribution schemes under a "veil of ignorance" about future income. The redistribution scheme is then enforced through social pressure: Those who comply exert a negative externality on the others. In this framework, some risk-sharing (ex post redistribution) might emerge. The political equilibrium is often such that a majority of people complies with the risk-sharing rule that matches with their own taste, while the others does not. In this case, the risk-sharing rule is welfare enhancing for everybody. Yet the political equilibrium might be such that only a minority of people complies with a risk-sharing rule that maximizes the expected payoff of a non-compliant

[25] In contrast, in repeated game models of risk-sharing, hard work and success are less likely to be disapproved since being successful allow to give more to the risk-sharing partners.

person. In this case and if the level of compliance is sufficiently low, those who comply with the rule are worse off than without any risk-sharing rule.

I now conclude with two remarks. First, to keep the analysis tractable, I have assumed that people vote being ignorant over their income. A more realistic assumption would be to assume that people know their current revenue when they vote but they are uncertain about their future revenue as in Wright (1986). This assumption creates some heterogeneity among the voters. Following Wright (1986), one can expect that the richest ones would favor less redistribution compared to the poorest ones, especially if rich (poor) people are more likely to remain rich (poor) in the future. As a result, risk-sharing would still be uncomplete not only due to limited enforcement but also to fit with the tastes of rich people when they constitute a majority of voters as in Wright (1986).

Second, it might also be more realistic to put some restriction on the social sanction. Indeed, it seems unlikely that people feel guilty or are punished when a majority of people behave like them. The social sanction or utility loss from deviating from the rule should be effective only if a majority complies with the rule. This restriction on social sanction would obviously favor the best compliance risk-sharing rule (defined as the rule that maximizes the expected utility of those who comply). It would indeed be a Condorcet winner because any majority in favor of another rule would be composed by those who expect not to comply with it and, therefore, would never be enforced.

A Convexity

$\forall \mu : \underline{\mu} \geq \mu \geq \bar{\mu}$, $\tilde{\theta}(\mu) = \dfrac{u(\bar{y}) - u(\bar{y} - \alpha)}{[1 - p + p\mu]r}$. We have:

$$\tilde{\theta}'(\mu) = -p\frac{u(\bar{y}) - u(\bar{y} - t)}{(1 - p + p\mu)^2 s} < 0,$$

$$\tilde{\theta}''(\mu) = 2p^2 \frac{u(\bar{y}) - u(\bar{y} - t)}{(1 - p + p\mu)^3 s} > 0.$$

B Proof of Proposition 1

Suppose $U_c(t^c, r^c) \geq U_n(t^m, r^m, \theta_m)$. I show that (t^c, r^c) is a Condorcet winner. Consider another feasible risk-sharing rule (t', r'). By definition of (t^c, r^c), (t', r') can be preferred only by those who do not comply with it. Since $U_n(t', r', \theta_m) \leq U_n(t^m, r^m, \theta_m) < U_c(t^c, r^c)$, the median voter prefers (t^c, r^c) to (t', r'). Now, for any θ, using envelope theorem, we have:

$$\frac{dU_n(t^\theta, r^\theta, \theta)}{d\theta} = \frac{\partial U_n(t^\theta, r^\theta, \theta)}{\partial \theta} = -p(1 - p + \mu^* p)s,$$

where μ^* denotes the level of compliance which balances (t^θ, r^θ). Since the right-hand side is strictly negative, then for any $\theta > \theta_m$, $U_n(t', r', \theta_m) \leq U_n(t^\theta, r^\theta, \theta) \leq U_n(t^m, r^m, \theta_m) < U_c(t^c, r^c)$. Hence, all individuals $\theta \in [\theta_m, \bar{\theta}]$ prefer (t^c, r^c) to (t', r'). Since they constitute a majority, (t^c, r^c) is a Condorcet winner.

When $U_c(t^c, r^c) \geq U_n(t^m, r^m, \theta_m)$ and (t^c, r^c) is elected then agents with $\theta \in [\theta^m, \bar{\theta}]$ comply. They constitute a majority.

C Proof of Corollary 1

First suppose that everybody comply to complete risk-sharing, hereafter denoted (t^f, r^f). Then everybody gets in expectation $u(E[y])$ where $E[y] = p\bar{y} + (1 - p)\underline{y}$. Since the rule is designed to share risk and not to exacerbate it, the only alternative feasible rule is such that $t' < t^f$. Since it requires to pay less, still everybody comply with such a rule which means that everybody gets $U_c(t', r')$ in expectation. However, u concave implies $U_c(t', r') < u(E[y])$ so that everybody prefer (t^f, r^f) to any other feasible rule $t' < t^f$.

Second, suppose that (t^f, r^f) is elected. Suppose further that some persons do not comply to it, i.e. $\mu^* < 1$. Then (t^f, r^f) does not satisfy (11). In other words, it is not the compliant best risk-sharing rule which contradicts it is elected when $U_c(t^c, r^c) \geq U_n(t^{\theta_m}, r^{\theta_m}, \theta_m)$.

D Proof of Proposition 3

Consider the rule (t, r) that balances at the equilibrium level of compliance μ^*. $\mu^* pt = (1 - p)r$ and $\mu^* < \dfrac{u'(\bar{y})}{u'(\underline{y})}$ imply:

$$(1 - p)u'(\underline{y})r < u'(\bar{y})pt.$$

Furthermore, the concavity of u implies

$$u'(\underline{y})r \geq u(\underline{y}+r) - u(\underline{y}),$$

and,

$$u'(\bar{y})t \leq u(\bar{y}) - u(\bar{y}-t).$$

The three last inequalities imply,

$$(1-p)(u(\underline{y}+r) - u(\underline{y})) < p(u(\bar{y}) - u(\bar{y}-t)),$$

or, equivalently,

$$pu(\bar{y}-t) + (1-p)u(\underline{y}+r) < pu(\bar{y}) + (1-p)u(\underline{y}),$$

i.e., a complaint person's expected utility is lower with (t, r) than without informal risk-sharing.

E First and second order conditions

The best compliant rule (t^c, r^c) solves:

$$\max_{t,r} pu(\bar{y}-t) + (1-p)u(\underline{y}+r) \text{ subject to 3, 6 and 4.} \tag{14}$$

Substituting $r = \frac{p}{1-p}\mu^* t$ in the objective function yields the following first order condition is:

$$\frac{\partial U_c}{\partial t} + \frac{\partial U_c}{\partial r}\frac{dr}{dt} = 0.$$

That is:

$$p\{u'(\underline{y}+r^c) \quad \mu^* + t^c\frac{d\mu^*}{dt} \quad - u'(\bar{y}-t^c)\} = 0,$$

where $\dfrac{d\mu^*}{dt} = -\dfrac{f(\tilde{\theta}(\mu^*))\dfrac{u'(\bar{y}-t^c)}{(1-p+p\mu^*)s}}{1+f(\tilde{\theta}(\mu^*))\tilde{\theta}'(\mu^*)}$.

Since $1 + f(\tilde{\theta}(\mu^*))\tilde{\theta}'(\mu^*) > 0$ for a stable equilibrium, then $\dfrac{d\mu^*}{dt} < 0$.

I now verify the second-order condition. Since $\tilde{\theta}'(\mu^*) = -p\dfrac{u(\bar{y}) - u(\bar{y}-t)}{(1-p+p\mu^*)^2}$, the first derivative can be rewritten as:

$$p\{u'(\underline{y}+r)[\mu^* - \frac{f(\tilde{\theta}(\mu^*))t^c u'(\bar{y}-t^c)}{(1-p+p\mu^*)s - pf(\tilde{\theta}(\mu^*))\dfrac{u(\bar{y})-u(\bar{y}-t^c)}{1-p+p\mu^*}}] - u'(\bar{y}-t^c)\}.$$

Substitute $\tilde{\theta}(\mu^*) = \dfrac{u(\bar{y}) - u(\bar{y}-t^c)}{(1-p+p\mu^*)s}$ and rewrite the first derivative as,

$$p\{u'(\underline{y}+r^c)[\mu^* - \frac{f(\tilde{\theta}(\mu^*))t^c u'(\bar{y}-t^c)}{[1-p+p\mu^* - pf(\tilde{\theta}(\mu^*))\tilde{\theta}(\mu^*)]s}] - u'(\bar{y}-t^c)\}.$$

The second derivative is:

$$p\{u''(\underline{y}+r^c)\frac{p}{1-p}[\mu^* + t^c\frac{d\mu^*}{dt}]^2 + u'(\underline{y}+r^c)[\frac{d\mu^*}{dt} -$$
$$D\{u'(\bar{y}-t^c)[t^c f'(\tilde{\theta}(\mu^*))\frac{d\tilde{\theta}(\mu^*)}{dt} + f(\tilde{\theta}(\mu^*))] - f(\tilde{\theta}(\mu^*))t^c u''(\bar{y}-t^c)\} +$$
$$\frac{1}{D^2}\{f(\tilde{\theta}(\mu^*))t^c u'(\bar{y}-t^c)pr(\frac{d\mu^*}{dt} - f'(\tilde{\theta}(\mu^*))\frac{d\tilde{\theta}(\mu^*)}{dt}\tilde{\theta}(\mu^*) - f(\tilde{\theta}(\mu^*))\frac{d\tilde{\theta}(\mu^*)}{dt})\}] + u''(\bar{y}-t^c)\},$$

where $D = [1-p+p\mu^* - pf(\tilde{\theta}(\mu^*))\tilde{\theta}(\mu^*)]s > 0$ (because $\frac{d\mu^*}{dt} < 0$) and, $\frac{d\tilde{\theta}(\mu^*)}{dt} = \tilde{\theta}'(\mu^*)\frac{d\mu^*}{dt} + \frac{u'(\bar{y}-t^c)}{[1-p+p\mu^*]s} > 0$. Moreover, $u'' < 0$ and $f'(\theta) \geq 0$ for every $\theta \in \Theta$ by assumption. Hence, the second derivative is strictly negative.

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