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Pooling Promises with Moral Hazard*

Catarina Goulão

Toulouse School of Economics (GREMAQ and INRA)

Luca Panaccione†

Università degli Studi di Roma “Tor Vergata” (DEDI and CEIS)

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Abstract

In this paper, we extend the framework of Dubey and Geanakoplos (2002) to the case of moral hazard. Risk-averse consumers, who can influence the likelihood of states of nature by undertaking a hidden action, receive insurance by voluntarily participating in a pool of promises of deliveries of future uncertain endowments. In exchange, they gain the right to receive a share of the total return of the pool, in proportion to their promises. We first analyze the equilibrium properties of the model and then illustrate how an aggregate pool of promises of heterogeneous consumers, differing in expected endowment, results in a welfare improvement over the two segregated pools.

Keywords: moral hazard, pool of promises, heterogeneous consumers.

JEL Classification: D3, D8, G2.

1 Introduction

In this paper, we study a model in which risk-averse consumers face uncertain endowments. Consumers can influence the likelihood of the states of nature by undertaking a costly action. Since the action is unverifiable, there is moral hazard. Contrary to the traditional literature on insurance with moral hazard (see e.g. Arnott and Stiglitz 1988), we do not consider that consumers buy insurance contracts from perfectly competitive insurance companies. Instead, we assume that consumers commit to contribute a fraction of their endowments to a common pool, and, therefore, gain the right to receive a fraction of the total return of the pool proportional to their promises.

In particular, and as in Dubey and Geanakoplos (2002), consumers take the return of the pool as given and they are free to choose how much to promise to the pool. This feature allows for the possibility that consumers, although equal ex-ante, choose to promise differently, and, as a consequence, choose different actions. We verify that this possibility actually occurs,

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†Corresponding author: Dipartimento di Economia, Diritto e Istituzioni, Via Columbia 2, 00133 Roma, Italy; e-mail: luca.panaccione@uniroma2.it

28 as well as other possible equilibrium configurations in which all consumers make the same
 29 choice of action and promise. Additionally, we consider the case of ex-ante heterogeneous
 30 consumers, where one type of consumers has higher expected endowments than the other,
 31 conditional on choosing the same action. In this case, it could be conjectured that the
 32 wealthiest would prefer a pool only among themselves rather than a pool together with the
 33 poorest ones, as the latter would lower the pool's return. However, we provide an example
 34 showing that the wealthiest consumers have no loss in welfare by joining a pool together
 35 with the poorest ones, while the latter are better off. The crucial feature of this result relies on
 36 moral hazard, that is, on the possibility of influencing the value of expected endowments by
 37 choosing different actions. In the aggregate pool, the proportion of the wealthiest consumers
 38 choosing an action which positively affects the return of the pool is increased. This example
 39 illustrates how such a pool of voluntary promises can be used for redistribution purposes,
 40 as opposed to compulsory systems. This is a crucial feature of our model in contrast with
 41 other contributions that consider mutual arrangements in which participants have to pay a
 42 uniform contribution to the pool, see e.g. Guinnane and Streb (2011).

43 The framework first proposed by Dubey and Geanakoplos (2002) had, as its main purpose,
 44 to overcome the problem of existence of equilibrium in the competitive model with adverse
 45 selection of Rothschild and Stiglitz (1976). Other authors, since that time, have been ex-
 46 tending and applying their framework but most consider setups with adverse selection (see,
 47 among others, Martin (2007) and Fostel and Geanakoplos (2008)). To our knowledge our
 48 contribution is the first to consider a pool of promises as a means of insurance in the presence
 49 of moral hazard. In particular, we identify an equilibrium where ex-ante equal consumers
 50 end up choosing different actions and different consumption bundles, even though they are
 51 equivalent in terms of utility. This feature enables redistribution among consumers even
 52 when they are ex-ante heterogeneous, a case that we also consider.

53 Our paper is set out as follows: in section 2, we introduce the model; in section 3, we
 54 present our results, illustrate them through examples, and discuss their main implications.

55 2 The model

56 We consider a pure exchange economy with a single consumption good. The economy is
 57 populated by a large number of ex-ante identical consumers, and it lasts for two periods
 58 $t = 0, 1$. At $t = 0$ there is no consumption, and at $t = 1$ each consumer has verifiable
 59 endowments that depend on a state of nature. There are two possible states $s = G, B$, and
 60 we let $w = (w_G, w_B) \in \mathbb{R}_+^2$ denote the vector of endowment, with $w_G > w_B \geq 0$.

61 Consumers may influence the likelihood of states of nature by undertaking an action
 62 $a \in \mathcal{A} = \{L, H\}$, which is not verifiable, and thus information is asymmetric. Let π_a denote
 63 the probability of the state G when action a is chosen, with $1 > \pi_H > \pi_L > 0$. The
 64 (dis)utility of the action is c_a , and we assume $c_H > c_L = 0$. The tradeoff is thus clear: on
 65 the one hand, undertaking action H increases the likelihood of the state G where endowment
 66 is higher but, on the other hand, it is costly since it requires higher effort.

67 Preferences are represented by an expected utility function $U(x, a) : \mathbb{R}_+^2 \times \mathcal{A} \rightarrow \mathbb{R}$, which
 68 depends on a state contingent consumption bundle $x = (x_G, x_B) \in \mathbb{R}_+^2$ and action as follows:

$$U(x, a) := \pi_a u(x_G) + (1 - \pi_a) u(x_B) - c_a, \quad (1)$$

69 with u twice differentiable, strictly increasing and strictly concave.

70 2.1 The pool of promises

71 Since consumers are risk-averse, they prefer to smooth their consumption across idiosyncratic
 72 states. This can be accomplished by pooling the risk associated with individual endowments.
 73 Indeed, we assume that each consumer faces uncertainty independently of other consumers.
 74 This assumption, in addition to the fact that there is a large number of consumers, rules out
 75 aggregated uncertainty.

76 Inspired by Dubey and Geanakoplos (2002), we propose the following insurance mecha-
 77 nism: at $t = 0$, each consumer voluntarily promises to make a delivery to a common pool,
 78 proportional to his endowment at $t = 1$. In exchange, at $t = 1$, the consumer receives a
 79 share of the total resources of the pool in proportion to his promise, and not to his actual
 80 delivery. More precisely, suppose that a fraction q of consumers choose $a = H$ and promise
 81 θ_H , while a fraction $1 - q$ choose $a = L$ and promise θ_L . In this case, total deliveries to the
 82 pool equal $q\theta_H\bar{w}_H + (1 - q)\theta_L\bar{w}_L$, where $\bar{w}_a = \pi_a w_G + (1 - \pi_a)w_B$ is the average (aggregate)
 83 endowment when action a is undertaken. Obviously, probabilities, and hence the fraction
 84 of consumers in each state, depend on the action chosen by consumers. Let κ denote the
 85 return per promise, given by:

$$\kappa = \frac{q\theta_H\bar{w}_H + (1 - q)\theta_L\bar{w}_L}{q\theta_H + (1 - q)\theta_L}. \quad (2)$$

86 Note that, since all consumers participate in the pool, the idiosyncratic uncertainty is wiped
 87 out, hence κ is not state contingent. Additionally, (2) implies that $w_B < \bar{w}_L \leq \kappa \leq \bar{w}_H < w_G$,
 88 and therefore that net deliveries to the pool $\theta_a(w_s - \kappa)$ are positive for consumers in the
 89 good state of nature, and negative for consumers in the bad state, irrespective of the action
 90 chosen. Indeed, state contingent consumption bundles are given by:

$$x_s = w_s - \theta(w_s - \kappa), \quad (3)$$

91 with $s = G, B$. Hence, consumers in state G consume less than their endowment, while those
 92 in state B consume more than their endowment. Therefore, the pool actually works as an
 93 insurance mechanism.

94 2.2 Consumers' problem

95 Consumers take the return per promise κ as given and choose their promises and actions so
 96 as to maximize expected utility. Formally, the consumers' problem can be written as follows:

$$\max_{\theta \in \Theta, a \in \mathcal{A}} v(\theta, a) = \pi_a u(w_G - \theta(w_G - \kappa)) + (1 - \pi_a)u(w_B - \theta(w_B - \kappa)) - c_a, \quad (4)$$

97 where we have replaced (3) into (1), with $\Theta = [0, \bar{\theta}]$, and $\bar{\theta} = w_G/(w_G - \kappa)$ being the
 98 maximum value θ can take to ensure a non-negative x_G . In what follows, $\psi(\kappa) \subset \Theta \times \mathcal{A}$
 99 denotes the set of solutions to problem (4). It is easy to verify that $\psi(\kappa)$ is not empty.

100 Note that $0 \leq \theta$ implies $x_G \leq w_G$, and therefore negative insurance is ruled out. More-
 101 over, since $\bar{\theta} > 1$, overinsurance, that is $x_B > x_G$, is admitted. Also, state-contingent con-
 102 sumption levels are always non-negative. Indeed, $\theta \leq \bar{\theta}$ implies $x_G \geq 0$, and since $w_B < \kappa$,
 103 $\theta \geq 0$ also implies $x_B \geq 0$.

104 3 Results and discussion

105 In equilibrium, consumers maximize their utility by taking as given the return of the pool,
 106 which is endogenously determined in a consistent way. Therefore, we propose the following
 107 definition of equilibrium:

108 **Definition 3.1.** *An equilibrium with a pool of promises is $(\tilde{\theta}, \tilde{a}, \tilde{q}, \tilde{\kappa})$ such that:*

- 109 1. $(\tilde{\theta}, \tilde{a}) \in \psi(\tilde{\kappa})$,
- 110 2. $\tilde{\kappa}$ satisfies (2),
- 111 3. \tilde{q} satisfies:

- (a) $\tilde{q} = 0$ if $(\tilde{\theta}, \tilde{a}) \in \psi(\tilde{\kappa})$ implies $\tilde{a} = L$, (Action L Equilibrium)
- (b) $\tilde{q} = 1$ if $(\tilde{\theta}, \tilde{a}) \in \psi(\tilde{\kappa})$ implies $\tilde{a} = H$, (Action H Equilibrium)
- (c) $\tilde{q} \in (0, 1)$ otherwise. (Mixed Action Equilibrium)

112 The above definition states that the equilibrium values of q must be properly related to the
 113 optimal choices of consumers. In particular, $q = 0$ ($q = 1$) can only arise in equilibrium if
 114 $a = L$ ($a = H$) is the optimal choice for every consumer. Similarly, for $q \in (0, 1)$ to arise
 115 in equilibrium, both $a = H$ and $a = L$ must be optimal choices of consumers. In what
 116 follows, we first show that an action H equilibrium never arises (Proposition 1), and then we
 117 propose conditions for the existence of both the action L equilibrium and the mixed action
 equilibrium (Propositions 2 and 3, respectively).

118 **Proposition 1.** [IMPOSSIBILITY OF A HIGH COST ACTION EQUILIBRIUM]

119 *There cannot be an equilibrium in which all consumers undertake the action H, i.e., if*
 120 *$(\tilde{\theta}, H, \tilde{q}, \tilde{\kappa})$ is an equilibrium, then $\tilde{q} \neq 1$.*

121 *Proof.* Let $\phi(\kappa, a) \subset \Theta$ denote the solution set of $\max_{\theta \in \Theta} v(\theta, a)$, and $\chi(\kappa, \theta) \subset \mathcal{A}$ the
 122 solution set of $\max_{a \in \mathcal{A}} v(\theta, a)$. Both $\phi(\kappa, a)$ and $\chi(\kappa, \theta)$ are non empty and $\phi(\kappa, a)$ is a
 123 singleton, because of the strict concavity of u . Notice that $(\tilde{\theta}, \tilde{a}) \in \psi(\tilde{\kappa})$ implies $\tilde{\theta} = \phi(\tilde{\kappa}, \tilde{a})$
 124 and $\tilde{a} \in \chi(\tilde{\kappa}, \tilde{\theta})$. Now, suppose, by way of obtaining a contradiction, that $\tilde{q} = 1$. In this case,
 125 (2) implies $\tilde{\kappa} = \bar{w}_H$. If $(\tilde{\theta}, H)$ is an equilibrium choice, then $(\tilde{\theta}, H) \in \psi(\bar{w}_H)$. This implies, in
 126 particular, $H \in \chi(\bar{w}_H, \tilde{\theta})$ and, therefore, $v(\tilde{\theta}, H) \geq v(\tilde{\theta}, L)$. Moreover, $(\tilde{\theta}, H) \in \psi(\bar{w}_H)$ also
 127 implies $\tilde{\theta} = \phi(\bar{w}_H, H)$ and, therefore, $\tilde{\theta} = 1$! In this case, however, $v(\tilde{\theta}, L) > v(\tilde{\theta}, H)$, which
 128 is the desired contradiction. \square

129 Proposition 1 states that if $q = 1$ and $a = H$, then κ does not satisfy (2). Indeed, if consumers
 130 anticipate the high return per promise $\kappa = \bar{w}_H$, which is implied by $q = 1$, their optimal
 131 choice is actually to over insure themselves and to choose $a = L$. In the next proposition,
 132 we state the condition under which action L equilibrium exists.

133 **Proposition 2.** [POSSIBILITY OF A LOW COST ACTION EQUILIBRIUM]

134 *Let $\hat{\theta}_H = \phi(\bar{w}_L, H)$ and $\hat{\theta}_L = \phi(\bar{w}_L, L)$ be the consumers' optimal promises when $\kappa = \bar{w}_L$*
 135 *conditional on choosing, respectively, $a = H$ and $a = L$. If $v(\hat{\theta}_L, L) \geq v(\hat{\theta}_H, H)$, then a low*
 136 *action equilibrium exists.*

137 *Proof.* $\phi(\kappa, a)$ is introduced in Proposition 1. When $q = 0$, (2) implies $\kappa = \bar{w}_L$. If $\kappa = \bar{w}_L$,
 138 then consumers' optimal promise is $\hat{\theta}_L$ when $a = L$ and $\hat{\theta}_H$ when $a = H$. If $(\hat{\theta}_L, L)$ is
 139 preferred to $(\hat{\theta}_H, H)$, then indeed every consumer will choose $a = L$ and hence $q = 0$. \square

140 Proposition 2 states that if all consumers choose $a = L$, then κ satisfies (2) and, thus, it
 141 identifies a possible equilibrium. However, we are also interested in the possibility of a mixed
 142 action equilibrium. Yet, since consumers are ex-ante equal, this can only happen if they are
 143 all indifferent to undertaking action H or action L . Proposition 3 states the condition under
 144 which this happens.

145 **Proposition 3.** [POSSIBILITY OF A MIXED ACTION EQUILIBRIUM]

146 *If $v(\hat{\theta}_L, L) < v(\hat{\theta}_H, H)$, then a mixed action equilibrium exists.*

147 *Proof.* When $v(\hat{\theta}_L, L) < v(\hat{\theta}_H, H)$, by adapting lemma 3.2 in Hellwig (1983) it is possible to
 148 show that there exist $\hat{\kappa} \in (\bar{w}_L, \bar{w}_H)$, $\theta_H < 1$ and $\theta_L > 1$ such that $\psi(\hat{\kappa}) = \{(\theta_H, H), (\theta_L, L)\}$.
 149 In this case, by definition of equilibrium it must be that $\hat{\kappa}$ satisfies (2) and $q \in (0, 1)$. From
 150 (2) we get:

$$q = \left[1 + \frac{\theta_H (\hat{\kappa} - \bar{w}_H)}{\theta_L (\bar{w}_L - \hat{\kappa})} \right]^{-1}.$$

151 Since $\bar{w}_L < \hat{\kappa} < \bar{w}_H$, we immediately verify that $q \in (0, 1)$. \square

152 Proposition 3 says that there exists $\hat{\kappa}$ such that consumers are indifferent between either
 153 action H or L when choosing two different promises. In this case, they split into the two
 154 actions in the proportion $q \in (0, 1)$ required to ensure that $\hat{\kappa}$ satisfies (2).

155 Figure 1, inspired by Dubey and Geanakoplos (2002), illustrates a mixed action equilib-
 156 rium. The initial contingent endowments are $(w_G, 0)$. Indifference curves are steeper when
 157 $a = H$ than when $a = L$. Therefore, they cross below the certainty line and make a kink.¹
 158 Combining the two state contingent consumption levels, as given by (3), with a view to
 159 eliminating θ , we can relate x_B and x_G as follows:

$$x_B = \frac{(w_G - w_B)\kappa}{w_G - \kappa} - \left(\frac{\kappa - w_B}{w_G - \kappa} \right) x_G. \quad (5)$$

160 This equation shows that, by giving up $(w_G - \kappa)$ units of consumption in the state G , a
 161 consumer gets $(\kappa - w_B)$ units of consumption in the state B . In Figure 1, we plot three
 162 downward sloping lines corresponding to (5) when $\kappa = \bar{\kappa}, \hat{\kappa}, \underline{\kappa}$, where $\bar{\kappa} = \bar{w}_H$, $\underline{\kappa} = \bar{w}_L$, and
 163 $\hat{\kappa}$ is the value emerging in a mixed action equilibrium (Proposition 3).

164 Alternatively, we can relate the consumers' state contingent consumption levels, as given
 165 by (3), by eliminating κ :

$$x_B = x_G - (w_G - w_B)(1 - \theta). \quad (6)$$

166 This equation shows how much is left over for consumption in the bad state of nature for a
 167 promise θ . In particular, when $\theta = 1$, then $x_G = x_B$, and when $\theta < 1$ ($\theta > 1$), then $x_G > x_B$
 168 ($x_G < x_B$). In Figure 1 we plot two of these curves: one associated with the action H
 169 promise; and the other associated with the action L promise. These are the upward sloping

¹The locus of points where indifference curves corresponding to the same utility level cross is sometimes called the *switching locus*.

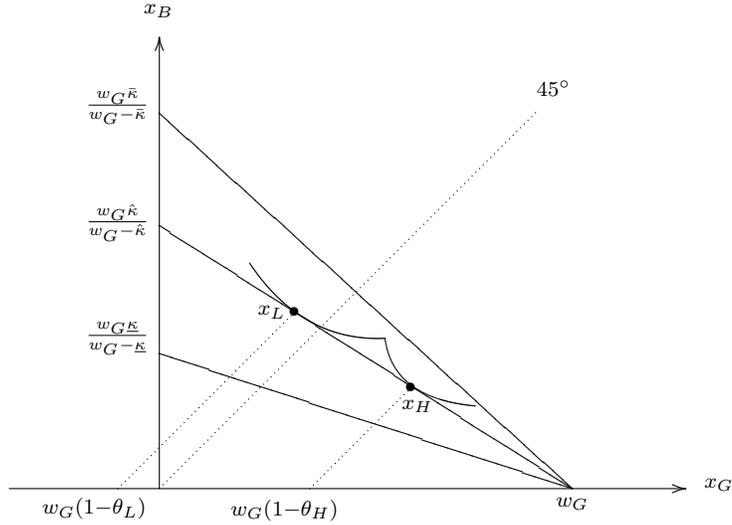


Figure 1: Mixed action equilibrium

170 curves, respectively below and above the 45° line. The mixed action equilibrium admissible
 171 consumption bundles are those at the intersection of the two lines identified by equations
 172 (5) and (6).

173 3.1 Examples of mixed action equilibria

174 We present three specific examples of mixed pools of promises. In the first two, we illustrate
 175 how mixed action equilibria appear. The third example aims to show the Pareto dominance
 176 of a mixed pool of promises among rich and poor individuals when compared to the two
 177 segregated pools of rich on the one side and poor individuals on the other.

178 **Example 1:** Let $u(x) = \log(x)$, $w = (1.5, 0)$, $c_H = 0.21$, and $(\pi_H, \pi_L) = (2/3, 1/3)$. In
 179 the mixed action equilibrium, $\hat{\kappa} = 0.52$ and $\hat{q} = 0.1$. In this case, $\psi(\hat{\kappa}) = \{(0.51, H), (1.02, L)\}$.
 180 The level of utility achieved is $v(\theta_H, H) = v(\theta_L, L) = -0.65$, where $\theta_H = 0.51$ and $\theta_L = 1.02$.

181 **Example 2:** Let $u(x) = x^\gamma/\gamma$ with $\gamma = 0.5$, $w = (1, 0)$, $c_H = 0.163$, and $(\pi_H, \pi_L) = (2/$
 182 $3, 1/3)$. In the mixed action equilibrium, $\hat{\kappa} = 0.4$ and $\hat{q} = 0.56$. In this case, $\psi(\hat{\kappa}) =$
 183 $\{(0.23, H), (1.21, L)\}$. The level of utility achieved is $v(\theta_H, H) = v(\theta_L, L) = 1.27$, where
 184 $\theta_H = 0.23$ and $\theta_L = 1.21$.

185 **Example 3:** Suppose there exist two equally sized groups of poor (\mathcal{P}) and rich (\mathcal{R})
 186 consumers, with contingent endowments equal to, respectively, $w^{\mathcal{P}} = (1.5, 0)$ and $w^{\mathcal{R}} =$
 187 $(2, 0)$. Furthermore, we assume that, for individuals in both groups, $u(x) = \log(x)$, and
 188 $(\pi_H, \pi_L) = (2/3, 1/3)$. Finally, while we maintain $c_L^{\mathcal{R}} = c_L^{\mathcal{P}} = 0$, we assume that it is less
 189 costly for the rich to undertake $a = H$: $c_H^{\mathcal{R}} = 0.2$ and $c_H^{\mathcal{P}} = 0.21$. This assumption is natural
 190 when interpreted in terms of a better education that wealthier people receive in preventing
 191 health accidents (see Smith 1999 for a survey on the relation between wealth and health
 192 outcomes, and Case et al. 2002 and Currie 2009, which explore empirically the direction of
 193 the causality).

194 Consider first isolated pools of rich and poor individuals. Poor consumers alone face the
 195 same problem as in example 1 and, therefore, the same mixed action equilibrium emerges. On

196 the other hand, the pool of rich consumers generates the following mixed action equilibrium:
 197 $q = 0.1$, $\hat{\kappa} = 0.7$, and $\psi(\hat{k}) = \{(0.51, H), (1.02, L)\}$. Rich consumers achieve higher utility:
 198 $v(\theta_H, H) = v(\theta_L, L) = -0.35$, where $\theta_H = 0.51$ and $\theta_L = 1.02$.

199 We now consider the possibility that the two groups form a common pool. Let $q^{\mathcal{R}}$ and $q^{\mathcal{P}}$
 200 denote the proportion of rich and poor consumers choosing $a = H$. Moreover, we distinguish
 201 promises made by poor ($\theta^{\mathcal{P}}$) and rich ($\theta^{\mathcal{R}}$) consumers. On the other hand, both types of
 202 consumers benefit from the same return per promise from the common pool. As the two
 203 groups of consumers are of equal size, it is clear that the return per promise in this case is:

$$\kappa = \frac{\sum_i q^i \theta_H^i \bar{w}_H^i + \sum_i (1 - q^i) \theta_L^i \bar{w}_L^i}{\sum_i q^i \theta_H^i + \sum_i (1 - q^i) \theta_L^i}, \quad (7)$$

204 where $i = \mathcal{R}, \mathcal{P}$.² In this case, a mixed action equilibrium is characterized by $q^{\mathcal{P}} = 0$,
 205 $q^{\mathcal{R}} = 0.8$, $\hat{\kappa} = 0.7$, i.e., the return per promise is as high as the one of the pool of the
 206 rich alone, but higher than the return per promise of the pool of the poor alone. Moreover,
 207 $\psi^{\mathcal{P}}(\hat{k}) = \{(1.25, L)\}$ and $\psi^{\mathcal{R}}(\hat{k}) = \{(0.51, H), (1.02, L)\}$. Facing the same return per promise,
 208 the rich have no reason to choose differently, and therefore end up with the same level of
 209 utility. The poor consumers, on the other hand, face a higher return per promise, and,
 210 therefore, they promise more than when forming a pool of promises alone as in example 1:
 211 $v(\theta^{\mathcal{P}}, L) = -0.32$, where $\theta^{\mathcal{P}} = 1.25$.

212 The economy therefore gains from two different effects. Firstly, rich consumers are more
 213 active in preventing the bad state of nature, and this process increases the aggregate expected
 214 endowments. Secondly, rich consumers bear a lower cost in preventing the bad state of nature
 215 and this reduces the economy's overall cost of preventing accidents. In other words, the rich
 216 can, at no cost, redistribute towards the poor because they are wealthier and are more able
 217 to prevent bad outcomes.

218 3.2 Discussion

219 We analyze the pool of promises in a setting with ex-ante moral hazard, in which agents
 220 affect the probability distribution of events. This additional freedom allows that, besides the
 221 low effort equilibrium, it is also possible that economies end up in a mixed action equilibrium
 222 with some consumers undertaking action H . When a heterogeneous population is considered,
 223 we show how the rich, who are also more able, can redistribute towards the poor at no cost,
 224 i.e., the heterogenous pool Pareto dominates the two segregated pools.

225 The implementation of a mixed equilibrium is a natural question to raise. One can
 226 think of a pool organizer as allocating consumers to promise levels according to the q that
 227 guarantees a consistent return per promise. Again, consumers are completely indifferent to
 228 this process since, whatever their action, they end up with the same level of utility.

229 In our view this framework is of particular interest in developing countries. As Pauly
 230 et al 2006 suggest, it seems reasonable to think of insurance cooperatives as an adequate
 231 form of insurance organization for these countries. In fact, on the one hand, tax systems
 232 are often more deficient, which compromises a compulsory public insurance scheme. On the
 233 other hand, the population of these countries is poorer and more often excluded from the
 234 market. In developing countries, mutual insurance solutions have indeed emerged for smaller

²See the Appendix for the analytical derivation of the equilibrium of the pool of promises among rich and poor individuals.

235 communities. For example, Cabrales et al (2003) analyze a specific mutual fire insurance
 236 scheme used in Andorra, De Weerd and Dercon (2006) find evidence of risk-sharing across
 237 networks within a village of Tanzania, and Murgai et al (2002) study water transfers along
 238 two water courses in Pakistan. Additionally, we argue that a voluntary mutual insurance
 239 scheme, such as the pool of promises, could be implemented at the national level.

240 However, for an application to developing economies, it seems reasonable to extend this
 241 model so that it encompasses aggregate uncertainty. Another interesting extension is to
 242 consider the possibility of limiting promises. Limiting promises has the same effect that
 243 partial insurance has in standard models of moral hazard: it makes incentive compatible
 244 a high cost action enhancing consumers' welfare. However, in a heterogenous pool, the
 245 consequences of limiting promises are not as straightforward.

246 Appendix

247 Let $\lambda^{\mathcal{R}}$ and $\lambda^{\mathcal{P}}$ denote, respectively, the proportion of rich and poor consumers, with
 248 $\lambda^{\mathcal{R}} + \lambda^{\mathcal{P}} = 1$. Moreover, let $\bar{w}^{\mathcal{R}}$ and $\bar{w}^{\mathcal{P}}$ be the expected endowments of, respectively,
 249 the former and the latter, with $\bar{w}^{\mathcal{R}} > \bar{w}^{\mathcal{P}}$. Note that the total expected endowments that
 250 an aggregate pool can guarantee to its members ($\lambda^{\mathcal{R}}\bar{w}^{\mathcal{R}} + \lambda^{\mathcal{P}}\bar{w}^{\mathcal{P}}$) is lower than $\bar{w}^{\mathcal{R}}$, the
 251 expected endowment a segregated pool of rich alone can guarantee to its members.

252 When an aggregated pool is formed, its return per promise depends on the deliveries of
 253 both types of consumers as follows:

$$\kappa = \frac{\sum_i \lambda^i q^i \theta_H^i \bar{w}_H^i + \sum_i \lambda^i (1 - q^i) \theta_L^i \bar{w}_L^i}{\sum_i \lambda^i q^i \theta_H^i + \sum_i \lambda^i (1 - q^i) \theta_L^i}. \quad (8)$$

254 We propose the following definition of equilibrium of the aggregated pool:

255 **Definition 3.2.** *An equilibrium with aggregate pool of promises is $(\tilde{\theta}^i, \tilde{a}^i, \tilde{q}^i, \tilde{\kappa})$, such that,*
 256 *for $i \in \{\mathcal{P}, \mathcal{R}\}$:*

- 257 (1) $(\tilde{\theta}^i, \tilde{a}^i) \in \psi^i(\tilde{\kappa})$,
- 258 (2) $\tilde{\kappa}$ satisfies (8),
- 259 (3) \tilde{q}^i satisfies:
 - 260 (a) $\tilde{q}^i = 0$ if $(\tilde{\theta}^i, \tilde{a}^i) \in \psi^i(\tilde{\kappa}) \Rightarrow \tilde{a}^i = L, \forall i$,
 - 261 (b) $\tilde{q}^i = 1$ if $(\tilde{\theta}^i, \tilde{a}^i) \in \psi^i(\tilde{\kappa}) \Rightarrow \tilde{a}^i = H \forall i$,
 - 262 (c) $\tilde{q}^i \in (0, 1)$ otherwise.

263 In the case of the heterogeneous pool of promises, an equilibrium with a mixed (aggregate)
 264 pool of promises is such that $q = \sum_i \lambda^i q^i \in (0, 1)$. Also let $\hat{\kappa}^i$ represent the critical return
 265 per promise of group $i \in \{\mathcal{P}, \mathcal{R}\}$ above (below) which type i consumers choose to do action
 266 L (H). It is straightforward to check that $\hat{\kappa}$ is increasing in endowment, for $u(x) = \log(x)$,
 267 as used in examples 1 and 3. Thus, $\hat{\kappa}^{\mathcal{R}} > \hat{\kappa}^{\mathcal{P}}$. Consequently, considering a candidate
 268 equilibrium κ , one of the following configurations may occur:

- 269 1. $\hat{\kappa}^{\mathcal{P}} < \hat{\kappa}^{\mathcal{R}} < \kappa$, and both poor and rich choose action L . Hence, $q = 0$.
- 270 2. $\hat{\kappa}^{\mathcal{P}} < \hat{\kappa}^{\mathcal{R}} = \kappa$, and poor choose action L while rich are indifferent. Hence, $q^{\mathcal{P}} = 0$,
 271 $q^{\mathcal{R}} \in (0, 1)$, and $q \in (0, 1)$.
- 272 3. $\hat{\kappa}^{\mathcal{P}} < \kappa < \hat{\kappa}^{\mathcal{R}}$, and poor choose action L while rich choose action H . Hence, $q^{\mathcal{P}} = 0$,
 273 $q^{\mathcal{R}} = 1$, and $q \in (0, 1)$.

- 274 4. $\hat{\kappa}^P = \kappa < \hat{\kappa}^R$, and poor are indifferent while rich choose action H . Hence, $q^P \in (0, 1)$,
 275 $q^R = 1$, and $q \in (0, 1)$.
- 276 5. $\kappa < \hat{\kappa}^P < \hat{\kappa}^R$, and both poor and rich choose action H . Hence, $q = 1$.

277 Note that case 5 can never arise in equilibrium, as follows from Proposition 1. In the text
 278 we illustrate case 2 type of equilibrium.

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