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Abstract

In this paper we consider the institutional arrangements needed in a decentralised framework to cope with the potential adverse welfare effects caused by localized negative shocks (e.g., natural disasters, terrorist attacks, or even clinical errors) that can be limited by precautionary investments. We model the role of a public mutual fund to cover these "collective risks". We start from the under-investment problem stemming from the moral hazard of Local administrations when the fund is managed by the Central government, which also takes into account the equalisation of resources across administrations. We then study the potential role of private insurers in solving the under-investment problem. Our analysis shows that the public fund is always superior to the private insurance solution in the presence of hard budget constraints. However, when the Central government cannot credibly commit to an optimal transfer rule, private insurers are sometimes able to improve on the public mutual fund solution by inducing a higher level of investments.

JEL Codes: H23, H77, G22

Keywords: intergovernmental relations, private insurer, collective risks

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1. Introduction

People suffer and die from fires, floods, or earthquakes that strike the area they live in because of unprepared and ineffective responses when the disasters occurred. People suffer and die as a consequence of terrorist attacks because security agencies are inaccurate or make mistakes in processing relevant information. People face severe limitations in their abilities or die because of inadequate organization in the provision of medical care in local hospitals. In all of these and several other examples that can be classified as *collective risks borne by local communities*, two questions are put at the forefront of public discussion whenever an unfortunate event occurs: what can public administrations do to alleviate the adverse welfare effects on people hit by negative shocks? What should have been done in order to avoid the occurrence of these negative shocks? As for the first question, a transfer policy aimed at providing initial help by the government is usually called for. This expresses a common claim for solidarity toward those who suffered welfare losses. As for the second question, much of the damage (or some of its consequences at least) can be avoided by *investing in mitigation*. In the case of floods, for instance, dams and barriers can be built to reduce the likelihood of losses occurring, or the severity of damage; in the case of terrorist attacks, better organized intelligence services can be of great help.

The economic literature has almost neglected two features common to all these situations: first, the ex-post transfer is implemented by the Central government, which assigns financial resources to local administrations (municipalities, regions, or hospitals). In this case, as shown by the vast amount of literature on fiscal federalism, a potential problem of opportunistic behaviour by local levels of government can emerge (on this specific point, Wildasin, 2008). Second, local administrations often buy coverage on private insurance markets, transferring risks to private companies (e.g. CEA, 2007).

The consequences of these intergovernmental relations has received little attention in the literature. The possibility that the ex-post transfer can influence the ex-ante precautionary investment has been investigated only by Goodspeed and Haughwout (2007), and Wildasin (2008). For this reason, the fact that a public administration should insure itself is a very intriguing question, that has never been addressed before as far as we know. As has been suggested by the literature on public bankruptcies (see e.g. McConnell and Picker, 1993), the imposition of new taxes, at least in principle, is in fact a remedy for coping with welfare losses that no private insurer can duplicate, and thus makes private insurance a Pareto-inferior solution in a *centralised* framework. To put it differently, as Arrow and Lind (1970) have shown, the expected utility losses are approximately zero as the number of taxpayers becomes larger and larger. In other words, in a centralised framework, the costs of risk-bearing can be optimally spread throughout the community by central government.

In this paper, we build on the work by Goodspeed and Haughwout (2007) and analyse the potential role of private insurers in solving the under-investment problem in protection stemming from the moral hazard of local administrations in a *decentralised* framework. In particular, we compare the welfare properties of a public mutual fund with those of a compulsory private insurance for local administrations, both in the case of a hard or a soft budget constraint. These two institutional arrangements require local administrations to pay a contribution – implicit in the case of the mutual fund, explicit in the case of a premium to be paid to an insurer – in order to obtain coverage for local collective risks. Our analysis shows that a public fund is always superior to the private insurance solution in the presence of hard budget constraints for local administrations. However, when the central government cannot credibly commit to an optimal transfer rule, private insurers are sometimes able to improve on the mutual public fund solution by inducing a higher level of precautionary investments. The main intuition for these results is that while the public mutual fund operates with *ex-post* contributions defined on the *actual* realisation of losses, private insurers need to define an *ex-ante* premium. This latter mechanism is less efficient in terms of providing the right incentives to invest in protection because – contributions being equal – the public fund mechanism provides more equality among local administrations.

The remainder of the paper is structured as follows: Section 2 describes the baseline model, and the outcome in the presence of a mutual fund, both under a hard and a soft budget constraint regime. The role of private insurers is discussed in Section 3. Section 4 discusses the results and Section 5 briefly concludes the paper.

2. The baseline model

Our analysis is based on a very simple and stylised model in the vein of Goodspeed and Haughwout (2007). We consider a game where a Federal ("Central") government interacts with N lower level ("Local") administrations. One can think of these actors as Regional (or State) governments, or some other local autonomous public bodies such as schools, hospitals, or universities. The main differences between the two layers of governments are related to the assignment of taxing power and to the management of public assets. Only the Central government retains the power to tax citizens, whereas this right is not awarded to Local administrations. The latter are entitled to manage some public assets that face a specific type of risk. Local administrations, for example, can reduce potential losses by investing in protection, but these investments are not observable by the Central government.

The Central government C defines ex-ante a global budget $N\boldsymbol{\Omega}$ of total transfers to Local (identical) administrations to be used for three main purposes: (a) current expenditures; (b) precautionary investments; (c) repayment of losses. As discussed in the introduction, many different examples fit into this general framework. Think for instance about the severe problem of damage to the environment caused by fires or floods, where precautionary investments are programmed at the regional level. Before moving further, notice that in our model the global budget is fixed to $N\boldsymbol{\Omega}$, even though the distribution of funds to the Local administrations might be discretionary in certain circumstances. We will analyse different scenarios, depending on whether the Central government is able to commit ex-ante to a specific transfer rule or not. In the first decentralised situation we consider, the commitment to the transfer rule is credible (i.e. soft budget constraint problems are ruled out). This assumption is relaxed later in the paper.

There is only one period: precautionary investments exhaust their preventive impact during the period that also coincides with the electoral cycle, at both the local and central level. The timing of the game is defined as follows:

a) first, Central government announces a 'transfer rule' T, i.e. the amount of funds that will be transferred to each Local administration (T_1, T_2, …, T_N);
b) then, Local administrations (acting simultaneously) define the amount of resources to be invested in protection I. Investments are not verifiable by the Central government (i.e. transfers cannot be contingent to investments);
c) Nature determines the realisation of loss d_i in each single administration i, which are

assumed to be independent (i.e. Cov[d_i, d_j] = 0) and observable by all players.[1] To simplify the presentation of our argument, we also assume that d takes up only two possible outcomes D (> 0) and 0 with probability respectively $\delta(I)p$ and $(1 - \delta(I)p)$. Investments I clearly influence the loss probabilities[2]; we assume that $\partial\delta/\partial I < 0$, $\partial^2\delta/\partial I^2 > 0$, and we normalize $\delta(0) = 1$;

d) finally, the Central government implements the transfers automatically, according to the pre-determined transfer rule T, and each Local administration i is able to define the (ex-post) budget for current expenditure $x_i = T_i - I_i - d_i$.

Central government's payoff is represented by a generalised utilitarian social welfare function, defined explicitly on a standard efficiency-equality trade-off in order to account for both the total (expected) amount of current expenditures x_i and the (expected) inequality in expenditures among Local administrations:

$$\Pi_C = E\left[\sum_{i=1}^{N} x_i\right] - \alpha E\left[\sum_{i=1}^{N} (x_i - \bar{x})^2\right], \tag{1}$$

where $\bar{x}$ is the mean expenditure of Local administrations. Notice that α (> 0) accounts for the degree of inequality aversion of the Central government: the higher α, the higher the loss in utility stemming from inequality. Moreover, as the first term in Eq. (1) is the sum of current expenditures, Central government payoff shows a sort of "aversion" to losses, since it clearly reduces the expected current expenditures.[3]

Local administrations' payoffs are defined only on expected current expenditures:

$$\Pi_i = E[x_i]; \quad i = 1,\ldots,N \tag{2}$$

The intuition behind this formulation is quite simple: local politicians are rewarded for local

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[1] Notice that the independence assumption easily stems from the *localised* nature of these risks. Fires, floods, terrorist attacks, clinical mistakes are all investing in a *specific* local community, not a whole country.

[2] The literature (see for example Jullien *et al.*, 1999) distinguishes between protection investments (when the investment is aimed at reducing the probability of the adverse event) and prevention investments (when the investment is aimed at reducing the severity of the damage). In our setup, I is consequently a 'protection' investment.

[3] Notice that when α is null, Π_C is simply a *Benthamite* (utilitarian) social welfare function. For $\alpha > 0$, Π_C becomes a generalised (utilitarian) SWF, represented as a linear function of mean and variance of the current expenditures of the Local administrations. This is not new in the literature: see, e.g., Picard (2008) in the context of natural disasters, and Konrad and Seitz (2003) in the context of fiscal federalism.

expenditures, but not for investments in protection, which are not observable by assumption. Hence, the higher x_i, the higher the probability they will be re-elected. Notice that we have modelled Local administrations as risk-neutral players.

The transfer rule T defined ex-ante by the Central government takes into account the commitment to a global budget fixed to $N\boldsymbol{\Omega}$. However, T_i can be made contingent to the distribution of losses. If M is the number of Local administrations hit by losses D ($0 \leq M \leq N$), the transfer rule able to perform full mutualisation of losses is the following:

$$T_i(d_i) = \boldsymbol{\Omega} + d_i - \bar{d}(M) \tag{3a}$$

where $\bar{d}(M) = D\,M/N$ represents the average actual loss. In other words, the transfer rule expressed by Eq. (3a) can be interpreted as the sum of three components: (a) a symmetric flat transfer $\boldsymbol{\Omega}$; (b) a transfer from a 'mutuality fund' that repays each loss d_i ($d_i = D$ or 0); (c) a contribution to the 'mutuality fund', equal to the average realised loss $\bar{d}(M)$.

The Central government might prefer only a *partial* mutualisation of losses. The general form of the transfer rule is then:

$$T_i(d_i) = \boldsymbol{\Omega} + \vartheta\left[d_i - \bar{d}(M)\right] \tag{3b}$$

The second term, again, represents the working of the public mutual fund, composed of the reimbursement of losses ϑd_i, and the mutuality contribution $\vartheta \bar{d}(M)$ needed to finance (partial) reimbursements of losses. Clearly, $\vartheta \in [0,1]$ is the degree of mutuality, or namely the coverage.

The expected payoff for the Central government can then be expressed as:

$$\begin{aligned}\boldsymbol{\Pi}_C &= E\left[\sum_{i=1}^{N}(T_i - I_i - d_i)\right] - \alpha\, E\left[\sum_{i=1}^{N}(x_i - \bar{x})^2\right] = \\ &= N\boldsymbol{\Omega} - \sum_{i=1}^{N}\left(I_i + \delta(I_i)\hat{d}_0\right) - \alpha(1-\vartheta)^2\boldsymbol{\Psi}(N, \delta(I_1), \ldots, \delta(I_N))\end{aligned} \tag{4}$$

where $\hat{d}_0 = D\,p$ is the *expected* loss in the absence of any investments, and:

$$\Psi(N,\delta(I)) = \sum_{M=0}^{N} \pi(M)\frac{M(N-M)}{N}D^2 = \qquad (4a)$$

$$= D\sum_{M=0}^{N} \frac{N!}{M!(N-M)!}[\delta(I)p]^M[1-\delta(I)p]^{(N-M)}(N-M)\bar{d}(M).$$

Each term of the sum represents the variance of current expenditures among local administrations in the specific state of nature when M shocks occurred, weighted for the probability of such state of nature $\pi(M)$. Notice that the first term in Eq. (4) (i.e. $E[\Sigma x_i]$) does not directly depend on ϑ since ϑ only affects the level of compensating transfers (added to some Local administrations and subtracted from others).[4] The term Ψ does not depend on ϑ either, and decreases as N increases.[5]

Finally, the payoff of Local administration i is the following:[6]

$$\Pi_i = E[T_i - I_i - d_i] = \qquad (5)$$

$$= \Omega + \vartheta\delta(I_i)\hat{d}_0 - \vartheta E\left[\sum_{M=0}^{N}\pi(M)\bar{d}(M)\right] - I_i - \delta(I_i)\hat{d}_0 =$$

$$= \Omega - I_i - (1-\vartheta)\delta(I_i)\hat{d}_0 - \frac{\vartheta}{N}\sum_{j=1}^{N}\delta(I_j)\hat{d}_0.$$

2.1. The benchmark case: full centralisation

We begin our analysis by defining a benchmark case, without any strategic interaction between different layers of government, and considering all decisions to be centralised. In this case, Central government defines both the transfer T and investments I in each Local administration. Remember that since Local administrations are identical, it follows that $I_i=I$

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4 As will soon become clear, the transfer rule indeed affects the investment strategies of the Local administrations, thus defining the ultimate amount of the budget that is free for current expenditures.

5 As is evident in Eq. [4a], given N, Ψ is increased in particular by the terms where $(N - M)$ and M assume similar values. When damage is uncommon, the probability of such states of nature decreases when the number of administrations (N) is greater.

6 Notice that the payoffs expressed in Eq. (4) and (5) are obtained assuming that losses can take only two possible outcomes, an hypothesis we maintain throughout the paper. Clearly enough, this assumption of a binomial distribution of losses is made only to simplify presentation. All of our results can be easily interpreted in the more general framework also, where losses are distributed according to a generic probability density function including those describing extreme events as discussed in Wildasin (2008). In this framework, the average actual loss $\bar{d}(M)$ and the average expected loss in the absence of precautionary investments $\hat{d}_0$ are still defined accordingly. The definition of Ψ becomes more complex, but it retains the property of independence from ϑ, and of a negative correlation with N.

$\forall i$. The Central government problem can then be simplified to:

$$max_{I,\vartheta}\,\Pi_C = max_{I,\vartheta}\left\{N\left[\Omega - I - \delta(I)\hat{d}_0\right] - \alpha(1-\vartheta)^2\Psi(N,\delta(I))\right\} \tag{6}$$

Central government first determines ϑ (given *I*), then selects the amount of resources to be invested in protection *I*. The F.O.C. for the solution of the problem is:

$$\frac{\partial \Pi_C}{\partial \vartheta} = 2\alpha(1-\vartheta)\Psi(N,\delta(I)) = 0 \tag{7}$$

which bring us to the optimal 'degree of mutuality' ϑ^{*c} = 1 (where superscript *c* is a mnemonic for 'centralised'). Notice that ϑ^{*c} is determined by looking solely at the 'equality component' of the Central government's payoff function. Given the fixed budget $N\Omega$, the result is not surprising: Local administrations will be sharing losses, whenever they occur. ϑ^{*c} makes null the second term of Eq. (1) (the equality component): consequently, given ϑ^{*c}, the Central government defines the optimal investment in protection I to be implemented, by maximising the 'efficiency component' of its payoff:

$$max_I\left[\Omega - I - \delta(I)\hat{d}_0\right] \tag{8}$$

The F.O.C. implies:

$$1 = -\frac{\partial \delta(I)}{\partial I}\hat{d}_0 \tag{9}$$

which implicitly characterizes the optimal investment I^{*c}. Interpretation of Eq. (9) is straightforward: marginal benefits of investing in protection (given by the marginal reduction in the value of expected losses) equals marginal costs.

2.2. The decentralised case: the public mutual fund with credible commitment

In the benchmark case all decisions are centralised. However, in most real-world cases, precautionary investment are in the hands of Local administrations; and these can decide their amounts, which Central government cannot observe. We solve the game by backward induction, and look for sub-game perfect Nash equilibrium. We then begin with the decision of Local administrations to invest, and then we analyse the definition of the transfer rule T (i.e. the level of ϑ) by the Central government.

When each Local administration decides the optimal investments to be implemented, given ϑ, it will maximise its own expected payoff, considering only the total current expenditures

x in its administration. The problem to be solved by Local administration i (see Eq. (5)) amounts to:

$$max_{I_i} \Pi_i = max_{I_i}\left[-I_i-(1-\vartheta)\delta(I_i)\hat{d}_0+\Omega-\frac{\vartheta}{N}\sum_{j=1}^{N}\delta(I_j)\hat{d}_0\right] \tag{10}$$

The F.O.C. for the solution of the problem can then be written as:

$$1=-\frac{\partial\delta(I_i)}{\partial I_i}\left(1-\vartheta\frac{N-1}{N}\right)\hat{d}_0 \tag{11}$$

which implicitly defines the optimal investment I_i^*, which clearly depends on ϑ.

Given that the Local administrations are identical, we will of course have $I_i^* = I^{*d}\ \forall i$ (where now superscript d is mnemonic for 'decentralised'). Notice that – by simply comparing Eq. (9) with Eq. (11) – it is clear that protection investments are reduced with respect to the benchmark case, for every $\vartheta > 0$; moreover, I^{*d} decreases when N increases. This is a strategic effect stemming from ϑ itself: each Local administration prefers to free-ride on investments and spend in x; the free-riding effect being clearly emphasised when the number of Local administrations is greater. Indeed, own investments increase the probability that Local administration will subsidise the other ones for (potential) losses, and this clearly reduces the incentive to invest. There is then a *vertical externality*, quite common in the literature on fiscal federalism, which influences the optimal amount of ϑ that will be chosen by the Central government. Notice also that I^{*d} will be strictly positive even when $\vartheta = 1$.[7] As we will show in the next Section, the presence of free-riding marks a striking difference between public transfer rules and private insurance mechanisms: when insurers are involved, the premium paid by a specific Local administration is not affected by the realisation of losses, while in the public case, each realised loss increases the mutuality contribution, $\vartheta\bar{d}$, of each single administration (see Eq.(3b)).

Given the choice of the investments to be implemented by the Local administrations, Central government will then define the optimal transfer rule T, which amounts to defining the mutualisation degree ϑ, since the total budget $N\Omega$ is fixed. The optimal additional

[7] The optimal investment I^* monotonically decreases when ϑ and N increase, until it becomes zero. If the absolute value of $\delta'(0)$ is sufficiently high, I^* is positive in the whole range [0,1] of ϑ.

transfer ϑ^{*d} will stem from two countervailing effects: on the one hand, Central government has the incentive to fix ϑ^{*d} as close as possible to $\vartheta^{*c} = 1$ in order to guarantee equality among local constituencies; on the other hand, by guaranteeing full mutualisation of losses, it reduces the incentive of a Local administration to invest in *I*, since $\partial I^{*d}/\partial\vartheta < 0$. The problem to be solved can be written as:

$$max_{\vartheta}\,\Pi_C = max_{\vartheta}\left\{ N\left[\Omega - I - \delta(I)\hat{d}_0\right] - \underbrace{\alpha E\left[\sum_{i=1}^{N}(x_i - \bar{x})^2\right]}_{\alpha(1-\vartheta)^2\Psi(N,\delta(I))} \right\} \tag{12}$$

$$s.t. \quad I = I^{*d}(\vartheta)$$

F.O.C. for the solution of the problem is:

$$-N\frac{\partial I^{*d}}{\partial\vartheta}\left(1 + \hat{d}_0\frac{\partial\delta(I)}{\partial I}\right) = \alpha\frac{\partial E\left[\sum_{i=1}^{N}(x_i - \bar{x})^2\right]}{\partial\vartheta} \tag{13}$$

Eq. (13) shows the efficiency-equality trade-off implicit in the payoff function of the Central government.

First, one can notice that the LHS of Eq. (13) – which corresponds to $\frac{\partial E\left[\sum_{i=1}^{N}x_i\right]}{\partial\vartheta}$ – is always negative for every $\vartheta > 0$. Intuitively, the lower the additional transfer, the closer the investment will be to its efficient level, which in turn implies a better trade-off between investments and expected loss, hence higher current expenditures *x*. More formally, considering the F.O.C. in Eq. (11) and $\partial I^{*d}/\partial\vartheta < 0$, one can show that:

$$-N\frac{\partial I^{*d}}{\partial\vartheta}\left(1 + \hat{d}_0\frac{\partial\delta(I)}{\partial I}\right) = -\frac{\partial I^{*d}}{\partial\vartheta}\left(\hat{d}_0\frac{\partial\delta(I)}{\partial I}\vartheta\frac{N-1}{N}\right) < 0 \tag{14}$$

given $\vartheta > 0$.

Second, the function $E\left[\sum_{i=1}^{N}(x_i - \bar{x})^2\right]$ is always non-negative, and reaches a minimum at ϑ=1, when all losses are fully shared and expenditures equalised in every Local administrations. In particular, when $\vartheta < 1$, $E\left[\sum_{i=1}^{N}(x_i-\bar{x})^2\right]$ strictly decreases with ϑ, while for $\vartheta > 1$ the inequality component of the payoff of the Central government increases. As a consequence, the RHS of Eq. (11) assumes negative values in the $0 \leq \vartheta < 1$ range.

Moreover, note that if $\alpha = 0$ (i.e. the Central government cares only about efficiency), the F.O.C. reduces to Eq. (9) and investment will consequently be fixed like in the benchmark case. The higher α, the closer the additional transfer ϑ^{*d} will be to 1, hence $\frac{\partial \vartheta^{*d}(\alpha)}{\partial \alpha} > 0$.

We are now able to show the following Proposition 1:

Proposition 1: *The degree of mutuality in the case of decentralisation is lower than the one in the centralised case, i.e.* $\vartheta^{*d} < \vartheta^{*c} = 1$, *and* $\partial \vartheta^{*d}/\partial N < 0$. *Protection investments* I^{*d} *will be reduced with respect to the centralised case* I^{*c}, *unless Central government cares only about efficiency.*

Proof: Directly from discussion above, since LHS of Eq. (13) is always negative and RHS of Eq. (13) is negative only for $\vartheta^{*d} < 1$, it must be that the optimal degree of mutuality ϑ^{*d} is lower than the one in the centralised case $\vartheta^{*c} = 1$. As far as $\partial I^{*d}/\partial N < 0$, the optimal trade-off between efficiency and equality asks for stronger investment incentives, i.e. a lower ϑ, when the number of Local administrations increases. ■

Proposition 1 suggests that decentralisation almost always leads to an inefficient outcome: given the presence of a vertical externality stemming from the additional transfers in case of losses, precautionary investments will be reduced with respect to the centralised case. By fixing ϑ, the Central government trades off equality and efficiency: on the one hand, a lower ϑ is used to induce more incentives to invest in protection; on the other hand, ϑ must be higher in order to guarantee a sufficient degree of mutualisation of losses. Since we have ruled out commitment problems thus far, notice that the inefficiency stems *only* from the free-riding behaviour of Local administrations:[8] risk is mutualised amongst all the Local

[8] Interestingly, this idea of free-riding behaviour among local governments has received the attention of legislators. One example is the arrangement provided by Law 353/2000 in the case of forest fires in Italy. In the experimental period between 2000 and 2002, the Central government defined a budget of 10 million euro

administrations and the effort to lower the probability of negative events decreases the mutuality contribution $\vartheta\bar{d}$ for all the participants. This inefficiency will be magnified when the Central government is not able to credibly commit to a pre-determined level of financing, a point that will be discussed below.

2.3. The decentralised case: the public mutual fund when commitment is not credible

We have assumed so far that Central government is able to commit to a predetermined transfer rule and a predetermined budget. While this may be true in some situations, especially when the Central government cares only about efficiency, it is definitely difficult to sustain when *large* welfare losses occur. In the case of floods, earthquakes or other natural disasters, and more generally when there are huge losses, Central government might be not be able to renege on its ex-ante commitment. In other words, in all these cases, *after* the disaster occurred, Central government can step in and redefine the transfers ex-post.[9] Clearly enough, if Local administrations anticipate this move by the Central government, the announcement of the transfer rule at the first stage of the game is not credible. To be more precise, the actual transfer rule will be fixed *after* the state of nature (the level of damage in every Local administration) has been observed, and it will maximise ex-post the Central government's payoff.

The equilibrium strategies are easily obtained from the results of the previous section. Simply note that, since the first move of the Central government is "cheap talk", the sequence of moves are reversed here: at the final stage of the game, given protection investments are sunk once losses are realised, the transfer rule has no incentive role, and Central government maximises the equality component of its payoff by fixing $\vartheta^{*dnc}=1$ (whereas now superscript *dnc* is mnemonic for 'decentralised and no commitment'), regardless of what was announced before; moving backwards , each Local administration

per year (*NΩ* in our notation) to be distributed to regional governments. In turn, regions redistribute financial resources to various municipalities according to the following rule: half proportional to the size of the local forestry area; half inversely related to the ratio between the size of forestry land destroyed by fire and the original size of forested land. As noted by Pazienza and Beraldo (2004), the law "has tried to introduce a management of the financial resources used in the fight of forest fires in such a way as to discourage any form of free-rider behaviour that could be taken up by regional or other local authorities".

[9] Notice that this is a simple application of the well-known Samaritan's dilemma, a typical situation of time inconsistency of public policies. See the seminal paper by Buchanan (1975).

decides the optimal investments to be implemented, anticipating the optimal response of the Central government. The problem to be solved amounts to:

$$max_{I_i}\, \Pi_i = max_{I_i} \left\{ -I_i + \Omega - \frac{\sum_{j=1}^{N} \delta\left(I_j\right)\hat{d}_0}{N} \right\} \tag{15}$$

The F.O.C. for the solution of the problem can then be written as:

$$1 = -\frac{\partial \delta(I_i)}{\partial I_i}\frac{\hat{d}_0}{N}\ , \tag{16}$$

which can also be obtained directly from Eq. (11) by setting $\vartheta = 1$. Given our assumption of identical local administrations, the optimal investment implicit in Eq. [16] is symmetric, i.e. $I_i^* = I^{*dnc}$. Notice also that by simply comparing Eq. (16) with Eq. (11), protection investments are reduced by the inability of the Central government to commit to a predetermined transfer rule, since $\vartheta^{*d} < 1$ (see Proposition 1).

We are now able to show the following Corollary to Proposition 1:

Corollary to Proposition 1: *In the case of decentralisation, when Central government is unable to commit to a pre-determined transfer rule, protection investments I^{*dnc} will be reduced with respect to the case with perfect commitment I^{*d}, unless Central government cares only about efficiency.*

Proof: Directly from discussion above.■

Notice that I^{*dnc} will be strictly positive[10] because a loss d in each Local administration, *ceteris paribus*, increases the mutuality contribution, $\vartheta\bar{d}$, by the amount $\vartheta d/N$. However, for even a very small degree of inequality aversion by the Central government, the inability to commit to a pre-determined transfer rule will result in a lower level of investments in protection by Local administrations. Could the present situation be improved by allowing for a private insurance solution? This is what we will present in the next section of the paper.

[10] See footnote 7 again.

3. The role of private insurers

In the previous section of the paper we assumed that Local administrations can recover from losses only by resorting to additional transfers by the Central government. In many real world cases, however, Local administrations (as broadly defined before) buy insurance coverage from private providers. For instance, an extensive market for medical malpractice insurance has been developing in the U.S. (e.g. Sloan, Chepke, 2008), and in Italy, hospitals are forced by law to buy insurance contracts on the market to cover damage arising from clinical errors (e.g., Buzzacchi, Gracis, 2008). The Spanish Crop Insurance System involves co-operation between Spanish authorities and *Agroseguro*, an association of private insurance companies, to manage the risks and crises in the agriculture and livestock sectors (CEA, 2007). A similar arrangement is the French *Cat. Nat. System*, explicitly designed to cover the risks related to natural hazards (see De Marcellis-Warin, Michel-Kerjan, 2001). Therefore, one intriguing question is to understand the role of private providers as *substitutes* for the Central government mutual fund. Before moving on to a more formal analysis, we can list a number of advantages and disadvantages of private insurers. On the one hand, private insurers may be better suited than the Central government to observe a proxy for the realised investment in protection. On the other hand, in the case of imperfect competition in private insurance markets, for instance, private insurers will gain positive profits, hence extracting rent from the public administrations. To avoid easy arguments in favour of institutional arrangements where private insurers can play a role, we rule out these possibilities here. We assume perfectly competitive insurance markets and we then normalise loadings to zero[11]. Moreover, we hypothesise that private insurers can only observe realisation of losses, as the Central government is able to do.

In the presence of private insurers, the Central government will transfer the amount Ω to each Local administration, possibly leaving the private market the task of covering the risk of damage. The fair premium P charged by the insurer to the Local administration depends on the level of coverage λ, where λ is the share of total losses to be reimbursed. In

[11] It is worth noting that we have already assumed the cost of managing the mutual fund by the Central government to be zero as well.

particular, the premium is fixed equal to the expected loss, $P(\lambda)=\lambda\delta(I)\hat{d}_0$ and, in return, the Local administration receives the amount λd from the insurer.

A crucial point to be emphasised here is what distinguishes the private solution from the public one. The insurer gets from the Local administration a premium which is defined *ex-ante* (i.e. *before* the realisation of losses is known), and commits to repay *ex-post* a share λ of the actual loss. Conversely, the transfer rule T is wholly *contingent* on the distribution of realised losses. In other words, even the mutuality contribution $\vartheta\bar{d}(M)$ (see Eq (3b)) - which is a sort of 'premium' paid to the Central government - is determined on the basis of the damage actually realised.

Summing up, the funding mechanism of the Central government to the Local administration is very similar to the net flow of capital between the Local administration and the insurer: given a level of coverage $\vartheta = \lambda$, the term ϑd equals the amount paid out by the insurer, λd, while the mutuality contribution $\vartheta\bar{d}$ simply equals *actual* average loss instead of *expected* average loss, corresponding to the (fair) premium P.

The premium charged by the insurer needs to deal with the moral hazard problem due to the unobservability of investments (Shavell, 1979). In particular, the insurer anticipates the disciplining effect of co-insurance on the investment strategy of the insured, i.e. $P(\lambda)=\lambda\delta\left(I^{*Ins}(\lambda)\right)\hat{d}_0$ (where *Ins* is now a mnemonic for the 'private insurance' case). Let's first assume that the Local administration can freely choose the coverage level together with the investment I^{*Ins}:

$$max_{I_i,\lambda_i}\, \Pi_i = max_{I_i,\lambda_i}\left[\Omega - P(\lambda_i) - I_i - (1-\lambda_i)\delta(I_i)\hat{d}_0\right] \qquad (17)$$
$$s.t. \quad P(\lambda_i)=\lambda_i\delta\left(I^{*Ins}(\lambda)\right)\hat{d}_0$$

We drop subscript *i,* since each identical Local administration deals individually with a number of competitive private insurers.

Noticing that investments are fixed after λ has been chosen and the insurance premium represents a sunk cost, the F.O.C. for the solution of the problem is:

$$1 = -\frac{\partial\delta(I)}{\partial I}(1-\lambda)\hat{d}_0 \qquad (18)$$
$$\rightarrow I^{*Ins} = I^{*Ins}(\lambda)$$

and[12]:

$$\frac{\partial \Pi_i}{\partial \lambda}\Big|_{I^{*Ins}=I^{*Ins}(\lambda)} = 0 \rightarrow \frac{\partial\left[\Omega - I^{*Ins}(\lambda) - \delta\left(I^{*Ins}(\lambda)\right)\hat{d}_0\right]}{\partial \lambda} = 0 \tag{19}$$

$$\rightarrow -\frac{\partial \delta(I)}{\partial I}\frac{\partial I^{*Ins}}{\partial \lambda}\hat{d}_0 = \frac{\partial I^{*Ins}}{\partial \lambda} \rightarrow \frac{1}{1-\lambda} = 1 \rightarrow \lambda = 0$$

Summing up, none of the Local administrations purchases any coverage in the private insurance market, and the protection investments are fixed to the efficient level[13]. Since the Local administration is assumed to be risk-neutral. This result can be easily understood since the private insurer simply dilutes the investment incentives, and the optimal coverage is then the one that guarantees optimal individual incentives (see Eq. (9)). This solution – illustrated by Eq. (19) – maximizes E[Σx_i]. Recalling our previous discussion, when a Central government simply provides a flat transfer $\boldsymbol{\Omega}$ (i.e., ϑ = 0), the outcome is suboptimal given that - as we have already shown - minimal equality is obtained.

An alternative strategy for the Central government could be the requirement of a compulsory minimal coverage level, λ^m. The maximisation problem of the Central government is then the following:[14]

$$max_{\lambda^m}\ \Pi_C = max_{\lambda^m}\left\{N\left[\Omega - I \underbrace{- P\left(\lambda^m\right) - \left(1-\lambda^m\right)\delta(I)\hat{d}_0}_{-\delta(I)\hat{d}_0}\right] - \alpha\left(1-\lambda^m\right)^2 \Psi(N, \delta(I))\right\} \tag{20}$$

$$s.t.\quad I = I^{*Ins}\left(\lambda^m\right)$$

which implicitly defines the optimal coverage level λ^{*m}. The issue is then whether it is possible to obtain a larger payoff for the Central government if a minimal mandatory coverage λ^{*m} on the private market substitutes the public mechanism described in the previous sections. Remember that the optimal transfer rule depends on the 'credibility regime', i.e. it is T^{*d} when the Central government is credible, while it merely requests perfect ex-post equality when the commitment is not credible. By simply comparing Eq. (9)

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[12] Remember that $P(\lambda) - (1-\lambda)\delta(I)\hat{d}_0 = \delta(I)\hat{d}_0$.

[13] Notice that $\partial \Pi_i / \partial \lambda < 0$ when $\lambda > 0$.

[14] Again, the strategies of the Local administrations are symmetric, so that we can simplify notation to $I_i = I^{Ins}$ $\forall i$.

with Eq. (18), it is clear that if $\lambda^m > 0$, precautionary investments are reduced with respect to the benchmark case.[15] This is a strategic effect which is different from the free-rider problem in the decentralised solution: in the present case, no positive externality is generated by precautionary investments in each single Local administration on the cost of coverage of the other ones. Here the level of investments is suboptimal because the unit price of coverage increases with λ^m in order to discipline the moral hazard. Each Local administration thus prefers to retain the risk and devote more resources to current expenditures x. By imposing a minimal coverage, the Central government trades off efficiency and equality.

3.1. The case with credible commitment

We first compare the private insurance solution to the public mutual fund when the ex-ante commitment by the Central government is credible. Not surprisingly, since the net payments between the insurer and the Local administration are equal to the expected value of the transfer rule in the decentralized solution ($E[T_i]$), the expected payoff of the Central government does not change, given the level of investments I. The decentralised and the private insurance solutions can easily be compared thanks to the following Proposition 2:

Proposition 2: *The decentralised mutual solution always dominates the private insurance solution when the optimal transfer rule is credible.*

Proof: The (market) incentive schemes expressed by Eq. (18) can always be perfectly replicated by the Central government (see Eq.(11)), i.e. for every value $\tilde{\lambda}$, the degree of mutualisation $\tilde{\vartheta} = \frac{N}{N-1}\tilde{\lambda}$ generates equal incentive schemes. In other words, since $N/(N - 1) > 1$, the incentive mechanism provided by the decentralised solution is more powerful than the insurer's, namely, equal investments can be induced by the decentralised solution by means of higher coverage (hence higher equality).[16] For every pair

[15] Remember from footnote 13 that the Local administration will choose the minimal compulsory coverage. Again, this is due to the risk-neutrality assumption of the players. When the risk aversion of Local administrations is sufficiently high, there is no need to impose coverage.

[16] The reason is that when the coverage level is fixed, a higher investment I does not reduce the premium P, while it reduces the term $\vartheta \bar{d}(M)$ in T_i, because it is evaluated ex-post. This becomes evident considering that

($\tilde{\lambda},\tilde{\vartheta} \mid \tilde{\lambda} = \frac{N-1}{N}\tilde{\vartheta}; \tilde{\lambda} \in [0,1]$) it is possible to compare $\Pi^{d}{}_{C}(\tilde{\vartheta})$ with $\Pi^{Ins}{}_{C}(\tilde{\lambda})$. Since $I^{*d}(\tilde{\vartheta}) = I^{*Ins}(\tilde{\lambda})$, the efficiency component of the payoff is the same; consequently, $\Pi^{d}{}_{C}(\tilde{\vartheta}) > \Pi^{Ins}{}_{C}(\tilde{\lambda})$ if and only if $(1-\tilde{\lambda})^2 > (1-\tilde{\vartheta})^2$, which is always verified. ■

The decentralised scenario with a public mutual fund strictly dominates the private insurer solution when the number of Local administrations is finite. When the number of Local administrations tends to infinity, decentralised mutuality and private insurance become isomorphic, i.e. every strategy in both regimes can be perfectly replicated in the other so that $\Pi^{*d}{}_{C}(\vartheta^{*d}) = \Pi^{*Ins}{}_{C}(\lambda^{*Ins})$.[17]

3.2. The case when Central government is unable to commit

We now compare the private insurance solution to the public mutual fund when the Central government cannot credibly commit to a predetermined transfer rule. In this case, Central government is expected ex-post to perfectly equalise current expenditures among local administrations in every state of nature (i.e., to fix $\vartheta^{*dnc} = 1$). The incentive constraint for Local administrations is then expressed by Eq. (16), leading to a payoff for Central government which is given by:

$$\Pi^{dnc}{}_{C} = N\left[\Omega - I^{*dnc} - \delta\left(I^{*dnc}\right)\hat{d}_0\right] \tag{21}$$

When the Local administrations are insured, the payoff for the Central government is given by:

$$\Pi^{Ins}{}_{C} = N\left[\Omega - I^{*Ins}(\lambda) - \delta\left(I^{*Ins}(\lambda)\right)\hat{d}_0\right] - \alpha\Psi\left(N, \delta\left(I^{*Ins}(\lambda)\right)\right)(1-\lambda)^2 \tag{22}$$

The question is whether an optimal λ^{m} can be chosen such that $\Pi^{Ins}{}_{C} > \Pi^{dnc}{}_{C}$, or:

$$\left[\delta\left(I^{*dnc}\right)\hat{d}_0 + I^{*dnc}\right] - \left[\delta\left(I^{*Ins}(\lambda)\right)\hat{d}_0 + I^{*Ins}(\lambda)\right] > \frac{\alpha\Psi\left(N, \delta\left(I^{*Ins}(\lambda)\right)\right)(1-\lambda)^2}{N} \tag{23}$$

We need to distinguish between two cases based on the value of λ^{*m}, the optimal minimal

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complete insurance (i.e., λ = 1) generates null protection investments, while in the decentralised solution, even when ϑ = 1 protection investments are positive.

[17] Indeed, when N tends to infinity the cost of mutualisation for each single Local administration cannot be significantly reduced by its own protection investments.

degree of coverage imposed by the Central government. First remember that $\delta(I)\hat{d}_0 + I$ monotonically decreases with I, until its minimum for $I = I^{*c}$ (see Eq.(9)). Consequently, since both $I^{*Ins} < I^{*c}$ and $I^{*dnc} < I^{*c}$, $\left[\delta\left(I^{*dnc}\right)\hat{d}_0 + I^{*dnc}\right] - \left[\delta\left(I^{*Ins}(\lambda)\right)\hat{d}_0 + I^{*Ins}(\lambda)\right] > 0$ if and only if $I^{*dnc} < I^{*Ins}$.

If $\lambda^{*m} \geq (N-1)/N$, then $I^{*Ins}(\lambda^{*m}) < I^{*dnc}$:[18] LHS of Eq.(23) is negative and the condition is never verified (remember that RHS is always positive). The public solution gives better incentives to the Local administrations and perfect equality: the private market solution is then dominated by the decentralised public solution even when the Central government cannot credibly commit to an ex-ante defined transfer rule. In the interval $0 \leq \lambda^{*m} \leq (N-1)/N$, $I^{*Ins} \geq I^{*dnc}$ and $\delta(I^{*Ins}) < \delta(I^{*dnc})$. Consequently, LHS of Eq.(23) proves to be positive and the condition in Eq. (23) is verified for some combinations of the model's parameters. In particular, the private insurance market can generate higher payoffs for the Central government when, *ceteris paribus*: i) α is sufficiently low and/or the adverse events are very infrequent, i.e. when expected inequality is rather low or irrelevant, so that efficiency is more appreciated; ii) the productivity of protection investment is high, i.e. when the effect of better incentives is more valuable; iii) N is high, which implies a limited incentive advantage for the public solution. This discussion is summarised in the following:

Proposition 3: *When the Central government cannot commit to a predetermined optimal transfer rule, the decentralised mutual public fund solution always dominates the private insurance solution for* $\lambda^{*m} \geq (N-1)/N$. *Under specific combinations of parameters* α, p, δ, N, *the private insurance solution dominates the decentralised mutual public fund solution if* $0 \leq \lambda^{*m} < (N-1)/N$.

Proof: Directly from discussion above. ■

Proposition 3 suggests that even when the Central government is unable to commit to a predetermined level of transfers, the welfare-enhancing role of the private insurer is rather limited. Notice that this result, combined with Proposition 2, is obtained by assuming competitive insurance markets. As we discuss in the next Section, by introducing some

[18] This is easily obtained by comparing Eq. (11) with Eq. (18), recalling that $\vartheta^{*dnc} = 1$.

rents, the room for private insurers shrinks further.

4. Discussion

In this section we discuss our findings, which can be summarised as follows: (a) when the Central government can credibly commit to a predetermined transfer rule, the public mutual solution is a welfare-superior institutional arrangement compared to the private insurance solution, since it is possible to obtain the same incentives to invest in protection while providing a higher degree of equality; (b) when the Central government is unable to commit to an ex-ante optimal transfer rule, the private insurance solution (if insurance markets are competitive) might improve welfare with respect to the public mutual fund when: i) the number of local administrations is large; ii) the degree of inequality aversion is low; iii) the probability for damage to occur is low; iv) the productivity of protection investments on the probability for damage to occur is large. At the equilibrium, the following inequalities hold:

$$\vartheta^{*d} < \lambda^{*m} < \vartheta^{*dnc} = \vartheta^{*c} = 1 \quad (24)$$

$$I^{*dnc} < I^{*Ins}, I^{*d} < I^{*c} \quad (25)$$

$$\Pi_C^{*dnc} < \Pi_C^{*Ins} < \Pi_C^{*d} < \Pi_C^{*c} \quad (26)$$

Given that the public mutual fund provides more incentives to invest than the private insurance solution, the Central government prefers equality over efficiency in the case of a private insurance solution; hence, $\lambda^{*m} > \vartheta^{*d}$ according to Eq. (24). This makes the comparison between I^{*Ins} and I^{*d} unclear. Since the public mutual fund is always better than the private insurance solution when the Central government can credibly commit to a predetermined transfer rule, this comparison is irrelevant however. According to Proposition 3, I^{*Ins} might be larger than I^{*dnc}, but this does not guarantee that $\Pi^{*Ins} > \Pi^{*dnc}$. Notice that in Eq. (25) and Eq. (26) we have ordered precautionary investments and Central government's payoffs assuming that the parameters of the model *assign* a welfare-improving role to private insurers.[19]

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[19] In other words, Eq. (25) and Eq. (26) are obtained assuming that Eq. (23) is satisfied. Otherwise, we obtain:

$$I^{*Ins} < I^{*dnc} < I^{*d} < I^{*c}$$

The rationale for these results is grounded in the institutional framework that we want to better illustrate in the rest of this section. Remember that in both institutional arrangements, local administrations pay a contribution – implicit in the case of the mutual fund, explicit in the case of a premium to be paid to an insurer – in order to obtain a coverage for these collective risks. However, while the public mutual fund operates with *ex-post* contributions defined on the *actual* realisation of losses, private insurers need to define an *ex-ante* premium. The second mechanism is less efficient in terms of providing the right incentives to invest in protection. This is so because, by providing the same level of coverage, the public fund mechanism provides more equality among local administrations.

The possibility that a private insurer could provide higher welfare in some specific regimes where Central government is unable to commit to a pre-determined transfer rule, can be explained by the different enforceability of the two "contracts". From this point of view, we have assumed that the contract with a private insurer is intrinsically more credible than the public fund mechanism. In the first case, the Local administration needs to pay an ex-ante premium P, and – in exchange – the insurer will reimburse a share λ of losses in case a damage occurs. Whenever one of the parties does not accomplish its contractual obligation, the other can recur to a civil court and ask for the enforcement of the contract. This enforcement is more credible than the one provided by an administrative or constitutional court, because the Central government can always renege on the commitment and – through a special law – pump more money into specific communities hit hard by a disaster. However, these conclusions are based on the hypothesis that the private insurer will never default. Otherwise, this enforceability advantage might disappear.

It is also worth noting that the mechanisms used by the Central government and by the private insurer in order to financially support the risks' coverage are actually associated with different risk profiles of these parties. The ex-ante definition of the premium of the private insurer implies that he is the one who bears the risk that the collected premiums (based on the *expected* losses) are insufficient to cover the ex-post *realised* losses. However, since we have not taken into account the cost of capital needed to finance coverage, no disadvantage for the private insurance solution emerges from this aspect. On the other hand, we have

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$$\Pi_C{}^{*Ins} < \Pi_C{}^{*dnc} < \Pi_C{}^{*d} < \Pi_C{}^{*c}$$

modelled the Central government as a player that perfectly commits to an aggregate transfer equal to $N\Omega$, so that he does not bear any risk similar to the one of the private insurer. However, in a more realistic situation the commitment to the ex-ante defined total transfer $N\Omega$, may be not credible. One might ask whether this situation could affect our results.

In particular, the Central government could be induced to increase *ex-post* equality by transferring funds from constituencies not hit by losses to those that are damaged, given that the private insurer only partially covers the Local administrations. Recalling what we have already illustrated in par. 2.3, the Central government always equalises expenditures *ex post* when its commitment is not credible. As a consequence, the disciplining role of partial coverage used by the private insurer ceases to exist: the Local administration keeps mitigation investments low, relying on the intervention of the Central government. Consequently, the premium requested by the private insurer will be associated with those low investments. Summarising, the private insurer definitely loses its welfare-enhancing role if the Central government is unable to credibly promise that he will not pay for damage that is not completely reimbursed by a private insurer.

A final difference is clearly in the private nature of the insurer, which maximises its profits. This is unlike the Central government, which aims at maximising welfare. If insurance markets are not perfectly competitive, there is an additional disadvantage of the private insurer solution which is not currently modelled in the paper, and further reinforces our main conclusions.

5. Concluding remarks

In this paper, we have considered the institutional arrangements needed in a decentralised framework to cope with the potential adverse welfare effects caused by such negative shocks as natural disasters, terrorist attacks or clinical errors, which can be 'limited' by precautionary investments. We build on the work by Goodspeed and Haughwout (2007), and we analyse the functioning of a public mutual fund aimed at covering losses from "collective risks" investing Local administrations. We then study the potential role of private insurers in solving the under-investment problem in protection that stems from the moral hazard of Local administrations facing a transfer rule by the Central government, which takes into account the equalisation of resources across Regions. Our analysis shows that a public fund is always superior to the private insurance solution in the presence of hard budget constraints for Local administrations. However, when the Central government cannot credibly commit to an optimal transfer rule, private insurers are sometimes able to improve on the mutual public fund solution by inducing a higher level of investments. An interesting issue that remains to be analysed is the superiority of a *mixed solution* (a sort of "public-private partnership"), where a public fund is combined with compulsory private insurances for Local administrations. This is left for future research.

References

Arrow K. J., Lind R. C., 1970, Uncertainty and the Evaluation of Public Investment Decisions, *American Economic Review*, 60(3), 364-378.

Buchanan, J.M., 1975, The Samaritan's dilemma, in: E.S. Phelps (ed.), *Altruism, Morality, and Economic Theory*, Sage Foundation, New York, 71-85.

Buzzacchi L., Gracis C., 2008, Meccanismi allocativi per il rischio sanitario nelle Aziende Sanitarie pubbliche italiane, *Mecosan*, XVII, 66, 103-122.

CEA, 2007, *Reducing the social and economic impact of climate change and natural catastrophes*, CEA: Brussels.

De Marcellis-Warin N., Michel-Kerjan E., 2001, The public-private sector risk-sharing in the French insurance "Cat. Nat. System", *Working Paper CIRANO*, 60.

Goodspeed T.J., Haughwout A., 2007, On the optimal design of disaster insurance in a federation, *CESifo Working Paper*, 1888.

Jullien B., Salanié B., Salanié F., 1999, Should more risk averse agents exert more effort? *The Geneva Papers of Risk and Insurance: Theory*, 24 (1), 19-28.

Konrad K. A., Seitz H., 2003, Fiscal Federalism and Risk Sharing in Germany: The Role of Size Differences, in S. Cnossen and H. W. Sinn, *Public Finance and Public Policy in the New Century*, MIT Press, Cambridge (MA), 469-489.

McConnell M. W., Picker R. C., 1993, When cities go broke: a conceptual introduction to municipal bankruptcy, *The University of Chicago Law Review*, 60 (2), 425-495.

Nekby L., 2004, Pure versus mutual health insurance: evidence from Swedish historical data, *The Journal of Risk and Insurance*, 71 (1), 115-134.

Pazienza P., Beraldo S., 2004, Adverse effects and responsibility of environmental policy: the case of forest fires, *Corporate Social Responsibility and Environmental Management*, 11(4), 222-231.

Picard P., 2008, Natural disaster insurance and the equity-efficiency trade-off, *The Journal of Risk and Insurance*, 75 (1), 17-38.

Shavell S., 1979, Risk sharing and incentives in the principal and agent relationship, *The Bell Journal of Economics*, 10, Spring, 55-73.

Sloan F. A., Chepke L. M., 2008, *Medical malpractice*, MIT Press, Cambridge (MA).

Smith B.D., Stutzer M., 1995, A theory of mutual formation and moral hazard with evidence from the history of the insurance industry, *The Review of Financial Studies*, 8 (2), 545-577.

Viswanathan K.S., Cummins J.D., 2003, Ownership structure changes in the insurance industry: an analysis of demutualization, *The Journal of Risk and Insurance*, 70 (3), 401-437.

Wildasin D.E., 2008, Disaster policies. Some implications for public finance in the U.S. Federation, *Public Finance Review*, 36(4), 497-518.

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