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Political decision of risk reduction: the role of trust

Meglena Jeleva · Stephane Rossignol

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Abstract Surveys concerning environmental and health risks point out the lack of trust of citizens in risk evaluations provided by governments. The aim of this paper is to take into account the impact of this potential distrust on political decisions concerning risk reduction. We prove that lack of trust reduces the attractiveness of risk reduction measures. When heterogeneity in risk exposure and the possibility of complete risk elimination are introduced, political decisions of risk reduction may differ from the preferred decision of any risk and trust group. Namely, total risk elimination can be adopted, even if all individuals prefer null or partial risk reduction measures.

Keywords Risk · Political decisions · Choquet expected utility preferences

JEL Classification D7 · D81

1 Introduction

Environmental, as well as health and food risks have taken, in the last few decades, a more and more important place in public debate. This is essentially due to uncertainties about the characteristics that render the determination of optimal decisions concerning the management of these risks particularly difficult. The precautionary principle[1] has been proposed to guide the authorities' actions concerning environmental and health risks in the presence

[1] The precautionary principle, formulated in Rio declaration in 1992, states that "if there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation".

M. Jeleva
GAINS-TEPP, University of Le Mans, Avenue O. Messiaen, 72085 Le Mans, France
e-mail: meglena.jeleva@univ-lemans.fr

S. Rossignol (✉)
LMV, University of Versailles, 45 Avenue des USA, 78035 Versailles Cedex, France
e-mail: rossignol@math.uvsq.fr

of scientific uncertainties. However, due to its general and imprecise formulation, it allows multiple interpretations that make it difficult to apply as a unique decision criterion (for a discussion on the controversies around the precautionary principle, see Godard 2003). Political decisions concerning risk management are guided not only by scientific knowledge, but also by individual preferences and beliefs. Beliefs are strongly influenced by public information, and trust in this information. Several surveys conducted in the member states of the European Union on different topics show that the trust of citizens in their government is far from being complete. For instance, in a Eurobarometer survey in 2004 on "The Attitudes of European citizens towards environment" it appears that only 11% of the respondents trust their national government to inform them about environmental problems. Another Eurobarometer survey in 2005 about radioactive waste confirms this result and even shows a decrease in trust: it appears that in 2005, 19% of the respondents trust their government when it informs them on the treatment of radioactive waste, whereas it was 29% in 2001. These results are confirmed by studies on general trust in government in the USA. Indeed, Lee and Clark (2001) underline the fact that trust in government has been declining since the 1960s decreasing from 75% in 1964 to 25% in 1994.

The aim of this paper is to study the impact of the lack of trust in the available information on political decisions concerning risk reduction. More precisely, we determine the risk reduction level that emerges from an electoral process where voters differ both in the confidence they have in the risk evaluation given by the authorities and in their wealth.

The trust level is taken into account by a model proposed by Jaffray (1988) and Cohen (1992) under risk and by Eichberger and Kelsey (1999) and Chateauneuf et al. (2007) under uncertainty. In this model, generalizing expected utility, beliefs are represented by a weighted sum of a probability distribution corresponding to the initial information, and two capacities characterizing complete uncertainty. The degree of confidence is then measured by the weight of the probability distribution (given in our context by the government) in the individual beliefs. With this choice criterion, a decision is evaluated by a combination of the standard expected utility of the decision and its best and worst consequences. This last element reflects the idea that if one does not believe at all in the available risk evaluation, one will consider oneself to be in a pure state of uncertainty and will take into account only the best and worst possible outcomes, according to the individual's degrees of pessimism-optimism.

The political decision criterion adopted here is that characteristic of a representative democracy modeled by probabilistic voting. Simple direct majority rule indeed does not seem to be well adapted for the risk decisions considered here for two reasons: (i) it would lead to a complete ignorance of risks affecting a small minority (which is not realistic) and (ii) in the case of several groups differing by more that one parameter, equilibrium may not exist. We assume that risk reduction is financed by a tax on wealth at a uniform rate.

Two types of risk are considered: global risks, which affect all voters equally (such as global warming, Genetically Modified Organisms (GMO) authorization and pandemics) and more specific risks for which risk groups can be identified, differing both by the estimated probabilities of the risk occurrence and by amounts of loss in the case of risk realization (such as risks issued from new drugs, new technologies, chemical plant installations etc.). For global risks, many risk reduction levels are available, going from the absence of any action to a complete risk elimination (if technologically possible). For specific risks, we assume that only three decisions are available: no action (status quo), complete risk elimination (by prohibition of the source of risk) and a given intermediate level of risk reduction.

The main results are the following.

Even if the risk is high, the politically chosen level of risk reduction will be low, if the average trust level is low. The impact of wealth on the risk reduction level depends both on the global wealth and on the wealth distribution between the different distrust level groups. The difference between the risk reduction level emerging from a political process and that preferred by an average individual depends on the individuals' degree of relative risk aversion. Moreover, it appears that in general, the political decision differs from the socially optimal one.

When only three decisions are possible: no action (status quo), partial reduction or complete risk eradication, and when individuals differ not only in their confidence level but also in their objective risk exposure, the optimal choice may differ from the best choices of all the individuals in the population: Condorcet type paradoxes are possible. These situations may occur when credible prohibition is not too costly with respect to partial reduction.

The paper starts with the presentation of the preferences representation model and the determination of the risk reduction level preferred by a given agent. We then study the politically chosen risk reduction level when individuals differ in wealth but are exposed to the same risk. The fourth section is devoted to the political decision when individuals differ in risk exposure.

2 The individually preferred risk reduction level

The aim of this section is to determine the level of risk reduction preferred by a given individual. This would be the implemented risk reduction level if the political decision was taken only with respect to this individual's preferences (or if this agent was a dictator). This analysis provides a benchmark for the general study of the political decision of risk reduction.

2.1 Individual preferences representation

We assume that the population is composed of n individuals with preferences towards wealth characterized by the same increasing and concave utility function u. Each individual faces a risk of loss, resulting from the occurrence of a catastrophic event E. The government provides an estimation of the probability distribution of the individual loss.

We assume that individuals do not completely trust the risk characteristics provided by the government. At least two reasons can explain this distrust:

- the risk is new and experts disagree on the estimation of the catastrophe probability that renders the "official" estimation, often based on an average value, not reliable.
- whatever is the subject, citizens lack of trust in their government.

This lack of confidence in probability estimations is well taken into account by a model in the Choquet expected utility class proposed by Chateauneuf et al. (2007).

In our context, the individual loss is a random variable X, taking its value in $\{x_0, x_1, \dots, x_l\}$, with $0 = x_0 < x_1 < \cdots < x_l = b$, where b is the maximal possible loss. The government gives the distribution P of X, i.e., the value of $P(X = x_i)$ for every i. The catastrophic event is $E = \{X > 0\}$, its probability estimated by the government is $p = P(E)$, and we set $V = E(X/X > 0)$ where V is the expected loss conditional to the occurrence of the catastrophic event.

The preferences representation issued from the model of Chateauneuf et al. (2007), of an individual with initial wealth y and with beliefs represented by the neo-capacity ν (see Appendix A for definition of ν and technical details about neo-capacities) can be written as:

$$W_\nu(y) = (1 - \varepsilon - \gamma) E_P(u(y) - X(\omega)) + \varepsilon \inf_{\omega \in \Omega} (u(y) - X(\omega)) + \gamma \sup_{\omega \in \Omega} (u(y) - X(\omega))$$

With this model, the individual welfare is a weighted sum of the standard expected utility with respect to the given probability distribution P and the utilities of the worst and the best possible outcomes. Here ε and γ reflect respectively the individual's pessimism and optimism, and $1-\varepsilon-\gamma$ measures the trust (or confidence) level in the government's probability estimation. Note that, for $\varepsilon=\gamma=0$, the beliefs coincide with the official estimation and the standard expected utility evaluation is obtained.

With our loss specification, the preferences representation becomes

$$\begin{aligned} W_\nu(y) &= (1-\varepsilon-\gamma)(u(y)-pE(X/X>0))+\varepsilon(u(y)-b)+\gamma(u(y)-0) \\ &= u(y)-\varepsilon b-(1-\varepsilon-\gamma)pV \end{aligned}$$

In the following, we set $\delta=\varepsilon+\gamma$, the distrust level, and thus the welfare becomes:

$$W_{\varepsilon,\delta}(y)=u(y)-\varepsilon b-(1-\delta)pV \quad \text{where } 0\le\varepsilon\le\delta\le 1$$

We see that the utility of the agent depends on the pessimism ε and on the distrust level δ. The optimism intervenes only through the distrust δ.[2]

2.2 The risk reduction level

A possibility of risk reduction is now introduced for the whole population. This risk reduction can take two forms, the first one corresponding to self-protection, and the other one to self insurance in the sense of Ehrlich and Becker (1972):

- a reduction of the *probability* of the catastrophic event which decreases from p to $(1-\lambda)p$, with $0\le\lambda\le 1$;
- a reduction of the *average loss* in the case of occurrence of E, which decreases from V to $(1-\lambda)V$, with $0\le\lambda\le 1$.

The distinction between these two types of risk reduction is often not obvious.

Note that the two types of risk reduction are equivalent in our model because the utility function is additively separable.[3]

[2] This is no longer true if we assume that the individual loss X may be negative, i.e. that the random event is an unexpected gain.

Let us assume that X takes its values in $\{x_0, x_1, \dots, x_l\}$, with $-a=x_0<x_1<\cdots<x_l=b$, where $a>0$, $b>0$, and b is the maximal possible loss, a is the maximal possible gain. Moreover $V=E(X/X\neq 0)$, and we assume that $V>0$ which means that the effect of risk remains globally negative. Here

$$W_\nu(y) = (1-\varepsilon-\gamma)E_P(u(y)-X(\omega))+\varepsilon \inf_{\omega\in\Omega}(u(y)-X(\omega))+\gamma \sup_{\omega\in\Omega}(u(y)-X(\omega))$$

$$W_\nu(y) = (1-\varepsilon-\gamma)(u(y)-pV)+\varepsilon(u(y)-b)+\gamma(u(y)+a)$$

$$W_\nu(y) = u(y)-\varepsilon b+\gamma a-(1-\delta)pV$$

The welfare with a risk reduction level λ given in (1) becomes

$$W_\nu(y)=u(y(1-t(\lambda,Y)))-\varepsilon b+\gamma a-(1-\lambda)(1-\delta)pV$$

When we derivate with respect to λ, the term γa vanishes, so all the first order conditions are unchanged.

In particular, (3) and (4) characterizing the preferred risk reduction level are still valid. We thank an anonymous referee for signaling us this extension.

[3] An example of risk reduction affecting both probability and average loss: the burying of radioactive waste reduces the probability of radionuclide contamination and the scale of the contamination.

We assume that the reduction of pV to $(1-\lambda)pV$ with $0 \le \lambda \le 1$ costs $T(\lambda)$.This cost is financed by a uniform tax rate $t(\lambda, Y) = \frac{T(\lambda)}{Y}$ where Y is the total wealth in the economy. Here $\lambda \mapsto T(\lambda)$ is assumed to be an increasing and convex function with $T(0) = 0$. Thus if $\lambda = 0$, the risk remains at its initial level, and if $\lambda = 1$ the risk is completely eliminated according to the government. However, if the agent is pessimistic (i.e., $\varepsilon > 0$), he will believe that the maximal loss is still possible even if $\lambda = 1$ (see the term $-\varepsilon b$ in (1)).

For an agent with distrust level δ, degree of pessimism ε, and income y, the evaluation of a risk reduction level λ gives:

$$W_{\varepsilon,\delta}(y, \lambda) = u(y(1 - t(\lambda, Y))) - \varepsilon b - (1 - \lambda)(1 - \delta)pV \tag{1}$$

Note that the distrust level δ determines the weight of the expected loss pV in the individual evaluation. If the distrust level is high, the individual is not very concerned by the average loss and focuses mainly on the maximal one. Consequently, a reduction of pV is more valuable for an individual whose distrust is low than for an individual whose distrust is high. At the extreme limit, an individual with maximal distrust level $\delta = 1$ will not include pV in his preferences representation and then will be in favor of no risk reduction at all.

The optimal risk reduction level λ^* for this agent is then the solution of the following maximization problem:

$$\max_{\lambda} u(y(1 - t(\lambda, Y))) - \varepsilon b - (1 - \lambda)(1 - \delta)pV \tag{2}$$

The first order condition for an internal solution is:

$$\frac{yT'(\lambda)}{Y} u'(y(1 - t(\lambda, Y))) = (1 - \delta)pV \tag{3}$$

The second order condition is satisfied for all $\lambda \in [0, 1]$ due to the concavity of u and to the convexity of T.

The optimal risk level equalizes the marginal benefit of risk reduction $(1-\delta)pV$ with its marginal cost in terms of utility $\frac{yT'(\lambda)}{Y} u'(y(1 - t(\lambda, Y)))$.

Note that the optimal risk reduction level $\lambda^* = \lambda^*(\delta, y)$ does not depend specifically on ε, but only on the global distrust level δ.

3 The political decision of risk reduction

We consider now a population composed of n individuals differing by their trust in the estimation of the risk announced by the government, by their pessimism, their wealth and their political weight. We aim to determine the level of risk reduction that will be implemented by the government.

3.1 The model of political decision

To simplify, we assume that there are k groups of homogenous individuals of size n_i, with $i = 1, \ldots, k$; their parameters of distrust and wealth are respectively δ_i and y_i with $i = 1, \ldots, k$. Pessimism and optimism levels are ε_i and γ_i respectively, with $\varepsilon_i + \gamma_i = \delta_i$. However, within a group, the agents can have preferences on other matters than the catastrophic risk. We model the political decision with probabilistic voting (see Persson and Tabellini

2000; Coughlin et al. 1990; Lindbeck and Weibull 1987, 1993). Two parties A and B compete in elections. Each party announces a policy, and it is assumed that the policy announced by the winning party will be implemented.

More precisely, the agent j of group i votes for party A iff

$$W_{\varepsilon_i,\delta_i}(y_i,\lambda_A)+b_{i,j}>W_{\varepsilon_i,\delta_i}(y_i,\lambda_B)$$

where λ_A and λ_B are the policies announced respectively by parties A and B. The welfare of any agent of group i is $W_{\varepsilon_i,\delta_i}(y_i,\lambda)$ if the policy λ is applied. The random variable $b_{i,j}$ measures the bias (positive or negative) of elector j in favor of party A, independently of policy λ. Within group i, the random variables $b_{i,j}$ have the same distribution as a random variable b_i, which is assumed to have a continuous distribution.

The mathematical expectation of the number of votes for A is

$$EW^A(\lambda_A,\lambda_B)=\sum_i\sum_j P(W_{\varepsilon_i,\delta_i}(y_i,\lambda_A)+b_{i,j}>W_{\varepsilon_i,\delta_i}(y_i,\lambda_B))$$

As all the $b_{i,j}$ have the same probability distribution as b_i, we have

$$EW^A(\lambda_A,\lambda_B)=\sum_i n_i P(W_{\varepsilon_i,\delta_i}(y_i,\lambda_A)+b_i>W_{\varepsilon_i,\delta_i}(y_i,\lambda_B))$$

and the mathematical expectation of the number of votes for B is

$$EW^B(\lambda_A,\lambda_B)=\sum_i n_i P(W_{\varepsilon_i,\delta_i}(y_i,\lambda_A)+b_i<W_{\varepsilon_i,\delta_i}(y_i,\lambda_B))$$

Let F_i denote the cumulative distribution function of b_i and f_i be its density. We obtain:

$$EW^B(\lambda_A,\lambda_B)=\sum_i n_i F_i(W_{\varepsilon_i,\delta_i}(y_i,\lambda_B)-W_{\varepsilon_i,\delta_i}(y_i,\lambda_A))$$

and

$$EW^A(\lambda_A,\lambda_B)=n-EW^B(\lambda_A,\lambda_B)$$

where $n=\sum_{i=1}^k n_i$ is the total number of agents.

Party B chooses λ_B to maximize $EW^B(\lambda_A,\lambda_B)$ (for λ_A given). The same is true for Party A. Thus the first order conditions are:

$$0=\sum_i n_i\frac{\partial W_{\varepsilon_i,\delta_i}(y_i,\lambda_B)}{\partial\lambda_B}f_i(W_{\varepsilon_i,\delta_i}(y_i,\lambda_B)-W_{\varepsilon_i,\delta_i}(y_i,\lambda_A))$$

$$0=\sum_i n_i\frac{\partial W_{\varepsilon_i,\delta_i}(y_i,\lambda_A)}{\partial\lambda_A}f_i(W_{\varepsilon_i,\delta_i}(y_i,\lambda_B)-W_{\varepsilon_i,\delta_i}(y_i,\lambda_A))$$

The two parties face the same problem. Thus at the Nash equilibrium, with simultaneous announcement of the policies, we have $\lambda_A=\lambda_B$, i.e.,

$$0=\sum_i n_i\frac{\partial W_{\varepsilon_i,\delta_i}(y_i,\lambda_B)}{\partial\lambda_B}f_i(0)$$

which is the FOC corresponding to the maximization of:

$$\sum_i n_i \alpha_i W_{\varepsilon_i,\delta_i}(y_i, \lambda_B)$$

for $\alpha_i = f_i(0)$.

We see that the political equilibrium implements the maximum of a sort of social welfare function, where each elector of group i is considered to have a weight $\alpha_i = f_i(0)$.

At the equilibrium, $f_i(0)$ is the density function of b_i. A high $f_i(0)$ means that the electors of group i will change their vote more easily if the policy proposed is modified. The political equilibrium then gives a greater weight to the individuals who are more prompt in changing their votes (from A to B or B to A).

3.2 Adopted risk reduction level

With the previous political decision model, the adopted risk reduction level λ^{**} will be the solution of the following optimization program:

$$\max_\lambda D(\lambda) = \sum_{i=1}^{k} \alpha_i n_i [u(y_i(1 - t(\lambda, Y))) - \varepsilon_i b - (1-\lambda)(1-\delta_i) pV]$$

where $t(\lambda, Y)$ is the uniform tax rate which finances a risk reduction corresponding to λ, given by $t(\lambda, Y) = \frac{T(\lambda)}{Y}$ with $Y = \sum_{i=1}^k n_i y_i$.

The agents choose to vote for A or B. At the equilibrium, parties A and B choose the same λ to maximize the electoral support function $D(\lambda)$, taking the parameters α_i, δ_i, ε_i, n_i, y_i, V, p, b as fixed.

The first order condition for an internal solution is:

$$D'(\lambda) = 0 \tag{4}$$

where

$$\begin{aligned} D'(\lambda) &= \sum_{i=1}^{k} \alpha_i n_i \left[-T'(\lambda) \frac{y_i}{Y} u'\left(y_i \left(1 - \frac{T(\lambda)}{Y} \right) \right) + (1-\delta_i) pV \right] \\ &= -\frac{T'(\lambda)}{Y} \left[\sum_{i=1}^{k} \alpha_i n_i y_i u'\left(y_i \left(1 - \frac{T(\lambda)}{Y} \right) \right) \right] + (1-\overline{\delta}) pV \sum_{i=1}^{k} \alpha_i n_i \end{aligned} \tag{5}$$

with $\overline{\delta} = \frac{\sum_{i=1}^k \alpha_i n_i \delta_i}{\sum_{i=1}^k \alpha_i n_i}$.

Moreover, setting $\overline{u}'(\lambda) = \frac{1}{\sum_{i=1}^k \alpha_i n_i} \sum_{i=1}^k \alpha_i n_i \frac{y_i}{Y} u'(y_i(1 - \frac{1}{Y} T(\lambda)))$, the first order condition becomes:

$$T'(\lambda) \overline{u}'(\lambda) = pV(1 - \overline{\delta}) \tag{6}$$

The second order condition is satisfied for any $\lambda \in [0, 1]$ because of the concavity of u and the convexity of T. As in (3), we obtain in (6) the equality of marginal utility and marginal cost of risk reduction. Note that, as in Sect. 2.2, the adopted risk reduction level depends here only on $\overline{\delta}$, and not specifically on the pessimism $\overline{\varepsilon}$.

It appears that preferences and trust levels of the different groups intervene in the government decision criterion via an "average" distrust level $\overline{\delta}$ and an "average" marginal cost (in terms of utility) $\overline{u}'(\lambda)$ which both depend not only on the size of each group, but also on their respective political weights.

In the particular case of a logarithmic utility function, $u(x) = \ln x$, the first order condition becomes:

$$\frac{T'(\lambda)}{(Y - T(\lambda))} = (1 - \overline{\delta})pV \tag{7}$$

This case has two specific features:

- only the total wealth in the economy influences the adopted level of risk reduction, the distribution of wealth between the groups of individuals plays no role.
- the political weight of a group has an influence on the adopted risk reduction level only via the average trust level in the population.

3.3 Some comparative static results

3.3.1 Impact of risk and trust level

In this section, we study the impact of an increase in the estimated probability of risk realization and the impact of an increase in the average distrust level on the politically chosen investment in risk reduction.

Proposition 1 *The level of risk reduction increases with the probability of risk occurrence and decreases with the average distrust level, i.e.,* $\frac{d\lambda^{**}}{dp} > 0$ *and* $\frac{d\lambda^{**}}{d\overline{\delta}} < 0$.

Proof From the first order condition (4), we have $\frac{d\lambda^{**}}{dp} = -\frac{1}{D''_{\lambda\lambda}} \frac{\partial D'_{\lambda}}{\partial p}$ and $\frac{d\lambda^{**}}{d\overline{\delta}} = -\frac{1}{D''_{\lambda\lambda}} \frac{\partial D'_{\lambda}}{\partial \overline{\delta}}$ where $D''_{\lambda\lambda} < 0$ from the second order condition of the optimization program.

Moreover, $\frac{\partial D'_{\lambda}}{\partial p} = V \sum_{i=1}^{k} \alpha_i n_i (1 - \delta_i) > 0$ and $\frac{\partial D'_{\lambda}}{\partial \overline{\delta}} = -pV \sum_{i=1}^{k} \alpha_i n_i < 0$. □

The first result implies that an increase in announced loss probability, ceteris paribus, leads to a higher investment in risk reduction. That corresponds to the standard results on optimal prevention, obtained by Ehrlich and Becker (1972).

From the second result, the optimal level of risk reduction decreases when average trust in government announcements deteriorates, i.e., when $\overline{\delta}$ increases. This result is specific to the adopted decision model and well emphasizes the particular role played by the trust level in the individual belief formation and in individual preferences. Indeed, the impacts of p and $\overline{\delta}$ on λ^{**} are opposite: if the government announces a higher probability of catastrophe, then the investment in risk reduction increases, whereas a decrease in the trust level decreases the perceived importance of the official average loss and thus the demand for risk reduction. Note that increases of optimism and of pessimism have the same impact on λ^{**} because they both induce a lower trust in risk reduction.

Different countries adopt different risk reduction levels (concerning environmental or health risks for instance). This may of course come from differences in official estimations of risks or in wealth, but here we propose another explanation. The previous proposition shows that countries with the same estimated risks may adopt different risk reductions if their governments face different trust levels. Several determinants of trust are identified in the literature: social polarization, income inequality and government performance (see Bjornskov 2007; Lee and Clark 2001).

One can note in addition that an increase in $\overline{\delta}$ can come here not only from a decrease in trust due to some government action, but also from an increase in the political weight of the group with the lower trust level (corresponding here to the higher δ_i).

3.3.2 Impact of wealth and political weight

Wealth can influence λ^{**} by two channels: via the global wealth in the economy and via the distribution of this wealth. We denote by $\beta_i = \frac{y_i}{Y}$ the proportion of the total wealth belonging to an individual of group i, for $i = 1, \dots, k$ and determine in the following proposition the impact of two types of wealth modifications: a proportional increase of all incomes (leaving β_i constant for any i), and a simple redistribution between two groups i and j (leaving Y constant).

Proposition 2

(i) *Risk reduction increases when the wealth of all individuals increase in the same proportion, i.e.,* $\frac{\partial \lambda^{**}}{\partial Y}|_{d\beta=0} > 0$.
(ii) *The impact of a modification in the wealth distribution depends on the relative risk aversion.*

For a constant relative risk aversion (CRRA) utility function, i.e., if $u(x) = \ln x$ *for* $R = 1$, *and* $u(x) = \frac{x^{1-R}}{1-R}$ *for* $R \neq 1$, *we have*:

– *if* $R = 1$ *then* $\frac{\partial \lambda^{**}}{\partial y_i}|_{dY=0} = 0$, *i.e., redistribution has no impact.*
– *if* $R \neq 1$, *then* $\frac{\partial \lambda^{**}}{\partial y_i}|_{\substack{dY=0,\ dy_l=0, \\ l\neq i,\ l\neq j}} > 0 \Leftrightarrow (R-1)(\frac{\alpha_i}{y_i^R} - \frac{\alpha_j}{y_j^R}) > 0$, *i.e., a redistribution from group* j *to group* i *increases the risk reduction level if for example* $R > 1$, *and group* i *is poorer but is more politically powerful than group* j.

Proof See Appendix. □

Consequently, it appears from (i) that risk reduction is as a normal good: investment in it increases with global wealth.

The impact of a redistribution depends on the relative risk aversion R. When the utility function is logarithmic, the risk reduction level is neutral concerning any redistribution of wealth between individuals in the population: only the total wealth matters. Thus if a fiscal reform modifies the distribution of wealth, with global wealth fixed, it will not change the risk reduction level.

On the other hand, when the utility function is CRRA with $R \neq 1$, the previous neutrality property no longer holds: a change in wealth distribution influences λ^{**} even if the total wealth remains constant. This is due to the fact that when $R \neq 1$ the marginal cost of risk reduction depends not only on the total wealth in the economy, but also on wealth distribution. Then, the variation of λ^{**} in the case of an increase in y_i, Y being constant, will result from two effects: group i becomes richer and thus, for $R > 1$, prefers more risk reduction (the marginal cost for risk reduction becomes lower for its members), whereas group j becomes less rich and thus prefers less risk reduction (the marginal cost for risk reduction becomes higher for its members).[4] Note that, for $R = 1$, the two effects compensate perfectly.

[4]Note that the opposite holds for $R < 1$.

The following proposition proves an intuitive result: an increase in the political weight of the individuals of a given group increases the politically chosen level of risk reduction if and only if the individuals in this group are in favour of a high risk reduction level.

Proposition 3 *If group i wants more risk reduction, then an increase of its political power induces more risk reduction*: $\frac{d\lambda^{**}}{d\alpha_i} > 0 \Leftrightarrow \lambda^*(\delta_i, y_i) > \lambda^{**}$.

Proof From (4) and (5), $\frac{d\lambda^{**}}{d\alpha_i} = -\frac{1}{D''_{\lambda\lambda}} \frac{\partial D'_\lambda}{\partial \alpha_i}$ which has the sign of $\frac{\partial D'_\lambda}{\partial \alpha_i}$.

$$\frac{\partial D'_\lambda}{\partial \alpha_i} = n_i \left(\frac{-y_i T'(\lambda^{**})}{Y} u'\left(y_i \left[1 - \frac{T(\lambda^{**})}{Y} \right] \right) + (1-\delta_i) p V \right) = n_i G'_i(\lambda^{**})$$

where $G_i(\lambda)$ is defined as $G_i(\lambda) = W_{\varepsilon_i,\delta_i}(y_i, \lambda)$ (see (1)).

$G''_i(\lambda) < 0$, i.e., G'_i is decreasing, and $G'_i(\lambda^*(\delta_i, y_i)) = 0$ thus $G'_i(\lambda^{**}) > 0 \Leftrightarrow \lambda^*(\delta_i, y_i) > \lambda^{**}$. □

3.3.3 *Comparison of λ^{**} with the individually and socially optimal risk reduction levels*

In the following we compare the politically chosen risk reduction level λ^{**} with the individually preferred risk reduction levels, and particularly the level preferred by an "average" individual, i.e., of average wealth $\bar{y} = \frac{\sum_i \alpha_i n_i y_i}{\sum_i \alpha_i n_i}$ and average trust level $\overline{\delta}$.

Proposition 4

(i) *The political decision is a compromise, i.e.*, $\lambda^{**} \in [\min_i \lambda^*(\delta_i, y_i),\ \max_i \lambda^*(\delta_i, y_i)]$;

(ii) *The political decision is not always that preferred by an average individual.*
In particular, for a CRRA utility function u, the gap between λ^{**} and $\lambda^*(\overline{\delta}, \bar{y})$ depends on the relative risk aversion R:

- *if* $R = 1$, *then* $\lambda^{**} = \lambda^*(\overline{\delta}, \bar{y})$
- *if* $R > 1$, *then* $\lambda^*(\overline{\delta}, \bar{y}) > \lambda^{**}$
- *if* $0 < R < 1$, *then* $\lambda^*(\overline{\delta}, \bar{y}) < \lambda^{**}$

(iii) *For any utility function u, if $y_i = y\ \forall i$ then* $\lambda^{**} = \lambda^*(\overline{\delta}, y)$.

Proof See Appendix. □

Proposition 4(i) compares λ^{**} with the individually optimal risk reduction levels: it appears that λ^{**} lies in the interval between the minimal and the maximal individually preferred risk reduction levels, which means that it corresponds to a compromise between the individually preferred risk reduction levels. We will prove in Sect. 4 that this is not always the case when the risk exposure is differentiated.

Concerning the comparison of λ^{**} with $\lambda^*(\overline{\delta}, \bar{y})$, when wealth is equally distributed between individuals or when the utility function is logarithmic ($R = 1$), the risk level adopted by the government does not differ from the one preferred by an individual with an average level of trust. It is however important to note that this average trust level depends not only on the respective sizes of the population groups, given by n_i, but also on their respective political weights, given by α_i. Thus, the trust level of group i will influence the decision more if this group is big and if its political weight is important.

For more general preferences, the comparison of λ^{**} and $\lambda^*(\overline{\delta}, \overline{y})$ depends on the degree of concavity of the utility function (measured by R). If R is greater than 1, the marginal utility of wealth is strongly decreasing, and the willingness to pay for risk reduction is proportionally much lower for poor people than for rich ones. That is why the political decision corresponds to less risk reduction than in the case where an "average" individual is considered.

In the following, we compare the risk reduction level λ^{**} resulting from a political process with the utilitarian risk reduction level λ^{opt} which maximizes the social welfare function $D(\lambda)$ corresponding to $\alpha_i = \alpha \ \forall i$, i.e., when the influence of each group corresponds to its demographic weight. It means that we compare a positive result λ^{**} with a normative one λ^{opt}.

Remark 1 Let λ^{opt} be the utilitarian optimal risk reduction level (obtained with identical political weight α for every agent). In general, $\lambda^{opt} \neq \lambda^{**}$. However, $\lambda^{opt} \in [\min_i \lambda^*(\delta_i, y_i), \max_i \lambda^*(\delta_i, y_i)]$.

More specifically, if $\alpha_i > \alpha$ for i such that $\lambda^*(\delta_i, y_i) > \lambda^{opt}$ and if $\alpha_i < \alpha$ for i such that $\lambda^*(\delta_i, y_i) < \lambda^{opt}$ then $\lambda^{**} > \lambda^{opt}$.

It appears that in general, the positive and the normative risk reduction levels are different. In particular, the positive level will be higher than the normative one if the individuals preferring greater risk reduction are the more politically influential ones.

3.3.4 The link between voting attitude and trust level[5]

In the previous sections, we have assumed that the political weights and the distrust levels are independent. However, it is a natural assumption to link the trust to the volatility of votes. More precisely we assume in this section that the individuals who are the more sensitive to a modification in the proposed policy are at the same time those whose distrust level is higher. We study then the impact of this positive relation between distrust and political weight on the adopted risk reduction level.

To focus on this point we assume now that:

- Hypothesis H1: $y_i = y$ for any i, i.e., all individuals have the same income.
- Hypothesis H2: $\alpha_i = \alpha \delta_i^c$ for any $i = 1..k$, where $\delta_i \leq \delta_{i+1}$ and $c \geq 0, \alpha > 0$, i.e., the political weight α_i is an increasing function of the distrust δ_i. The parameter c measures the strength of the link between the distrust levels and the political weights.

Proposition 5 *Under hypotheses H*1 *and H*2, *the stronger is the link between the political weights and the distrust levels*, *the lower is the adopted risk reduction level*, *i.e.*, $\frac{d\lambda^{**}}{dc} \leq 0$.

Proof See Appendix. □

The result proved in this proposition is in accordance with Propositions 1 and 3. When c increases, the relative political weights of the most distrustful groups increase. These groups prefer less risk reduction (see Proposition 1); an increase of their political influence reduces the adopted risk reduction level λ^{**} (see Proposition 3).

[5] We thank a referee for suggesting us this section.

4 Political decision with differentiated risk exposure

In this section, we consider risks deriving from a new product or a new technology, for which different risk groups may be identified: we assume more precisely that some individuals, by their location, or by their specific characteristics, are more exposed than others to risk. Moreover we assume that public authorities can eliminate completely these risks by forbidding the trade of the products or the use of the technology. In this case, since it is easier to verify that a product is forbidden than to evaluate the risk it generates when it is allowed, the government will be credible if it announces a total ban. Note however that forbidding a product or a technology has a cost (of lost consumer surplus, for example), since nobody will be able to use the product. This radical solution to the risk exposure problem can be opposed to two other solutions: risk reduction of level λ ($\lambda \in]0; 1[$), or total acceptance of the risk.

Three scenarios are then possible: authorization, reduction of risk, and prohibition.

We assume here that the agents differ in their risk p_i, average loss V_i and in their degrees of pessimism ε_i and optimism γ_i with $\gamma_i = \delta_i - \varepsilon_i$, where δ_i is the degree of distrust; in this section all agents are assumed to have the same income y. It means that, given the individual characteristics (age, profession, localization etc.), each agent i has an individual probability p_i of realization of the risk. The trust of agent i in the evaluation of the government is $1 - \delta_i$. In the three scenarios, we can evaluate the utility of an agent, which is a function of her income y, of her risk p_i, of her degree of pessimism ε_i and of her degree of trust $1 - \delta_i$. In the following, we set $Q_i = p_i V_i (1 - \delta_i)$. Here Q_i is the impact, in utility terms for the agent i, of the average loss $p_i V_i$. In other words, Q_i is the perceived average risk. The preferences of an agent can be sum up by her individual characteristics (ε_i, Q_i). The welfare of such an agent in the three scenarios is: Authorization

$$W_{author}(\varepsilon_i, Q_i) = u(y) - \varepsilon_i b - Q_i$$

Reduction of risk by a factor λ

$$W_{red}(\varepsilon_i, Q_i) = u(y(1-t)) - \varepsilon_i b - (1-\lambda) Q_i$$

Prohibition

$$W_{prohib}(\varepsilon_i, Q_i) = u(y(1-\theta))$$

where θy represents the individual cost of prohibition, and ty the individual cost of risk reduction.

To simplify, we assume that if the reduction of risk is chosen, this will be of a factor $\lambda \in]0; 1[$, λ given. To avoid the obvious case of prohibition preferred to reduction for every $\varepsilon_i, \delta_i, p_i$, we assume that $\theta > t > 0$.

4.1 Individual preference

We can examine now which scenario is preferred by an agent of type i: authorization, reduction of risk or prohibition.

We set:

$$E_1 = \{(\varepsilon_i, Q_i); W_{author}(\varepsilon_i, Q_i) = \max(W_{author}(\varepsilon_i, Q_i); W_{red}(\varepsilon_i, Q_i); W_{prohib}(\varepsilon_i, Q_i))\}$$

$$E_2 = \{(\varepsilon_i, Q_i); W_{red}(\varepsilon_i, Q_i) = \max(W_{author}(\varepsilon_i, Q_i); W_{red}(\varepsilon_i, Q_i); W_{prohib}(\varepsilon_i, Q_i))\}$$

$$E_3 = \{(\varepsilon_i, Q_i); W_{prohib}(\varepsilon_i, Q_i) = \max(W_{author}(\varepsilon_i, Q_i); W_{red}(\varepsilon_i, Q_i); W_{prohib}(\varepsilon_i, Q_i))\}$$

An agent with individual characteristics (ε_i, Q_i) prefers authorization iff $(\varepsilon_i, Q_i) \in E_1$. She prefers reduction of risk by a factor λ if $(\varepsilon_i, Q_i) \in E_2$, and she prefers prohibition if $(\varepsilon_i, Q_i) \in E_3$.

Proposition 6

(i) *There exists positive constants B_1, B_2, C_1, C_2, C_3 such that, for any individual of characteristics (ε_i, Q_i),*

$$\begin{aligned} W_{author}(\varepsilon_i, Q_i) \le W_{red}(\varepsilon_i, Q_i) \quad &\Longleftrightarrow \quad Q_i \ge C_3 \\ W_{author}(\varepsilon_i, Q_i) \le W_{prohib}(\varepsilon_i, Q_i) \quad &\Longleftrightarrow \quad Q_i \ge C_2\left(1 - \frac{\varepsilon_i}{B_2}\right) \\ W_{red}(\varepsilon_i, Q_i) \le W_{prohib}(\varepsilon_i, Q_i) \quad &\Longleftrightarrow \quad Q_i \ge C_1\left(1 - \frac{\varepsilon_i}{B_1}\right) \end{aligned} \tag{8}$$

(ii) *Case* 1: *if $C_1 < C_3$, nobody prefers risk reduction* (*see Fig.* 1).

(iii) *Case* 2: *if $C_1 \ge C_3$, some agents* (*with low ε_i and medium Q_i*) *prefer risk reduction* (*see Fig.* 2).

Proof See Appendix. □

An increase in C_3 reduces the attractiveness of reduction with respect to authorization: fewer agents will then prefer reduction, i.e., the set E_2 becomes smaller.

Similarly, a decrease in C_1 reduces the attractiveness of reduction with respect to prohibition: fewer agents will then prefer reduction, i.e., the set E_2 becomes smaller.

Consequently, when $C_3 > C_1$, the set E_2 becomes empty: nobody prefers reduction (see Fig. 1).

Fig. 1 Case 1

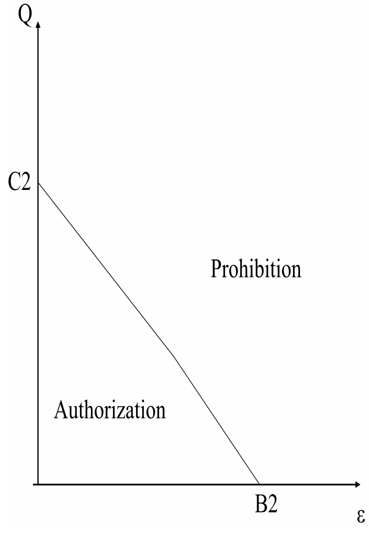
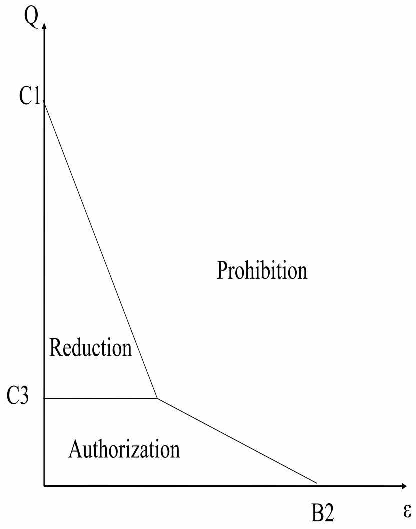


Fig. 2 Case 2



Let us denote by $z^*(\varepsilon_i, Q_i)$ the individual preference of an individual of characteristics (ε_i, Q_i), where we set $z^*(\varepsilon_i, Q_i) = j$ if $(\varepsilon_i, Q_i) \in E_j$, with $j \in \{1, 2, 3\}$.

Thus, $z^*(\varepsilon_i, Q_i) = 1$ means that individual i prefers authorization, $z^*(\varepsilon_i, Q_i) = 2$ means that individual i prefers risk reduction and $z^*(\varepsilon_i, Q_i) = 3$ means that individual i prefers prohibition.

Since prohibition is a more severe decision than reduction of risk, this one being more severe than authorization, the value of z^* is a measure of the severity of the decision concerning risk, as the value of λ^* was in Sect. 3 a measure of the intensity of risk reduction. This similarity allows an easier comparison of the decisions adopted in Sects. 3 and 4.

The following proposition gives some results about the impact of ε_i, and Q_i on the individual preferences $z^*(\varepsilon_i, Q_i)$.

Proposition 7 *An increase in pessimism or in perceived risk leads to a more cautious decision, i.e.,* $z^*(\varepsilon_i, Q_i)$ *is an increasing function with respect to* ε_i *and* Q_i.

Proof Obvious, if we look at Figs. 1 and 2. □

In particular, Proposition 7 means that an increase in the estimated probability p_i, leading to an increase in perceived average risk, Q_i, acts in favor of a more cautious decision concerning risk. Note that an increase in ε_i for Q_i constant may modify the decision from authorization to prohibition or from reduction to prohibition, but never from authorization to reduction as it appears in Fig. 2. Indeed, we see that if $(\varepsilon_i, Q_i) \in E_1$, then $(\varepsilon_i + h, Q_i) \notin E_2$ for any h.

Let us compare the results about the influence of the pessimism ε given in Proposition 1 and in Proposition 7. In Proposition 1, an increase in pessimism induces less risk reduction (since $\delta = \gamma + \varepsilon$). In Proposition 7, an increase in pessimism can lead to prohibition, which corresponds to extreme risk reduction. The opposition between these two results comes from the specific features of prohibition: in contrast with standard risk reduction, prohibition is perceived as a credible way for complete elimination of risk, whatever the individual trust level is.

4.2 The political choice

In this section, we consider the political choice concerning risk when the three previous possibilities can be chosen by the government. We keep the model of political choice by probabilistic voting. The population is constituted of k groups of homogenous individuals. Group i is composed of agents having the same characteristics (ε_i, Q_i). The chosen policy maximizes the political decision function:

$$D = \sum_{i=1}^{k} n_i \alpha_i W(\varepsilon_i, Q_i)$$

where α_i is the political weight of group i (as in Sect. 3). Three policies are available: authorization, reduction of risk by a given factor λ, and prohibition.

We denote by z^{**} the political decision. We set $z^{**} = 1$ if authorization is decided, $z^{**} = 2$ if reduction is decided, and $z^{**} = 3$ if it is prohibition.

Proposition 8

(i) *The political decision is that preferred by an average individual, i.e.*, $z^{**} = z^*(\overline{\varepsilon}, \overline{Q})$.
(ii) *If the individuals have the same preferred scenario, the political decision will correspond to this one.* $z^*(\varepsilon_i, Q_i) = z^*(\varepsilon_j, Q_j)$, *for any* $i, j = 1, \ldots, k \Rightarrow z^{**} = z^*(\varepsilon_i, Q_i)$.
(iii) *In Case* 1, *the political decision is always one of the individually preferred decisions, i.e.*, $z^{**} \in \{z^*(\varepsilon_i, Q_i), i = 1, \ldots, k\}$.
(iv) *In Case* 2, *the political decision is not always one of the individually preferred decisions, and can even be extreme, i.e.*, $z^{**} \notin [\min_i z^*(\varepsilon_i, Q_i); \max_i z^*(\varepsilon_i, Q_i)]$ *is possible* (*see Fig.* 3).

Proof See Appendix. □

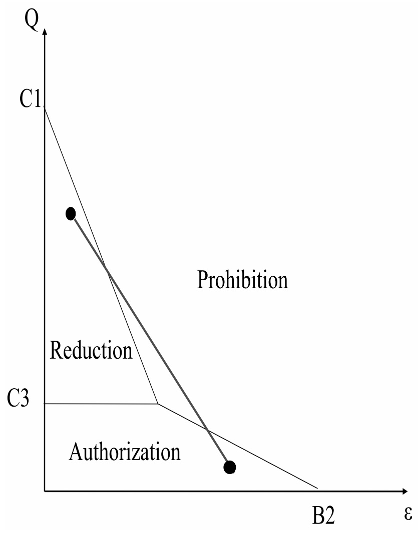


Fig. 3 An example of extreme decision

The political decision $z^{**} = z^*(\overline{\varepsilon}, \overline{Q})$ is that of an average individual even if nobody has his characteristics. The result (ii) in Proposition 8 comes from the convexity of the sets E_s: if $(\varepsilon_i, Q_i) \in E_s$ for all i, then $(\overline{\varepsilon}, \overline{Q}) \in E_s$.

In Case 1, according to Proposition 6(ii), only two decisions can be preferred: authorization and prohibition. Proposition 8(iii) is then due to the convexity of the sets E_s.

In Case 2, the adopted decision can be different from all the individually preferred decisions. Two types of situations can then occur: the adopted decision is a compromise (reduction is adopted whereas all individuals prefer authorization or prohibition), or the adopted decision is extreme (for instance, prohibition is adopted, whereas all individuals prefer authorization or reduction).

Thus, an extreme interpretation of the precautionary principle rejecting a new technology may come from a political process, even when every elector is ready to adopt this technology, without any restriction or under conditions of control of this technology. This can be due to a diversity of risk exposures, combined with a difference of trust levels (see Fig. 3).

This situation may occur with chemical products or nuclear technology, for example. We could then distinguish two types of agents: the first group comprises workers in the sector considered, as chemical professionals. They face a high risk, but they trust the evaluation of the risk, since in fact they are experts in the subject, and can understand how the risk has been estimated. They are in favour of a reduction of risk. The second group comprises the public or the product's users. They face a low risk but have a high degree of distrust. However they may be in favour of authorization if their risk Q is low and their degree of pessimism ε is not too high. They are sceptical about reduction. With these two groups, the political decision could be a ban of various types of chemical products or even of nuclear energy.

Proposition 8(iv) differs significantly from the corresponding one in Sect. 3, i.e., Proposition 4. Indeed, in Sect. 3, the political decision was in general different from that of an average individual; however it was always a compromise between the individually preferred decisions. This difference in results is linked to the specific features of prohibition, i.e., that it is a credible way to suppress risk: indeed it would vanish if prohibition was replaced by a maximal standard risk reduction corresponding to $\lambda = 1$, since this would not suppress the influence of distrust.

The following remark studies the impact of political weights on the political decision.

Remark 2 When α_i increases, with α_j fixed for all $j \neq i$, then $(\overline{\varepsilon}, \overline{Q})$ describes a segment of line and the political decision $z^{**} = z^*(\overline{\varepsilon}, \overline{Q})$ moves consequently. In Case 1, z^{**} variates monotonously. This is no longer true in Case 2. For example, we can have $z^{**} = 2$ for α_1 low, $z^{**} = 3$ for α_1 medium and $z^{**} = 1$ for α_1 high. This result is in contrast with Proposition 3.

Finally, in a last remark, we compare the utilitarian socially optimal decision z^{opt} with the political decision z^{**}. We note that z^{opt} may be an extreme decision, which was not possible in the framework of Sect. 3 (see Remark 1).

Remark 3 Let z^{opt} be the utilitarian socially optimal decision, i.e., obtained maximizing the social welfare function $D(\lambda)$ corresponding to $\alpha_1 = \alpha_2 = \cdots = \alpha_k$. In general, $z^{**} \neq z^{opt}$. Moreover, in Case 2 we can have $z^{opt} \notin [\min_i z^*(\varepsilon_i, Q_i); \max_i z^*(\varepsilon_i, Q_i)]$ and then the socially optimal decision can be extreme.

5 Conclusion

This paper is an attempt to introduce non-probabilistic uncertainty in a political economy model. More precisely, the probability of a catastrophic event is estimated by the government, but the individuals do not completely trust this estimation. We study then the politically chosen risk reduction level.

We find that this level of risk reduction increases with the estimated risk occurrence, but it is a decreasing function of the distrust level. This last result means that distrust here leads to passivity: the skepticism with regard to information given by the government leads to skepticism with regard to risk reduction. Consequently, rather than improving trust by reducing risk, governments must first restore trust in order to make risk reduction politically acceptable. One way to restore trust is to delegate research and risk information to independent agencies.

We show moreover that if all individuals are exposed to the same risk, the political decision and the socially optimal one are different in general but both lie between the individually preferred risk reduction levels.

This last result is not true for differentiated risk exposure. Political decisions in terms of risk reduction may then be extreme and far from the socially optimal one if individuals do not trust public information. Prohibition can then be politically chosen even if nobody prefers it, which corresponds to a radical interpretation of the precautionary principle. This situation would not occur if government restores sufficient trust.

To conclude, we think that our model can be considered as a first step in the introduction of behavioral economics insights in a political economy framework. It can be developed in several ways:

– The political decision of risk reduction can de studied when political parties or candidates have preferences on the policy applied, or they have different risk estimations.
– Distrust can concern only the efficiency of the risk reduction technology, rather than the risk estimation.

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Appendix A: Neo-capacities: definition and construction

In the model of Chateauneuf et al. (2007), beliefs are characterized, not by a probability distribution, but by a neo-additive capacity, defined in the following way:

Definition 1 Let Ω be a state space and $\mathcal{A}$ a σ-algebra of subsets of Ω. μ^0 and μ^1 are the capacities defined as follows:

- $\mu^0(\Omega) = 1$ and $\mu^0(A) = 0$ for all $A \in \mathcal{A}$, with $A \neq \Omega$;
- $\mu^1(\emptyset) = 0$ and $\mu^1(A) = 1$ for all $A \in \mathcal{A}$, with $A \neq \emptyset$.

For a given finitely additive probability distribution P on $(\Omega, \mathcal{A})$, a neo-additive capacity ν is defined as:

$$\nu(A) = (1 - \varepsilon - \gamma)P(A) + \varepsilon\mu^0(A) + \gamma\mu^1(A) \quad \text{with } \varepsilon \geq 0, \gamma \geq 0 \text{ and } \varepsilon + \gamma \leq 1$$

A neo-additive capacity is then a convex combination of a probability measure and two capacities, reflecting complete ignorance.

The weight $1-\varepsilon-\gamma$ given to P is a measure of the degree of confidence which an individual holds in this probability. In our framework, the neo-capacity ν associated with the official distribution P of X is such that:

$$\nu(E)=(1-\varepsilon-\gamma)p+\gamma \quad \text{and} \quad \nu(\overline{E})=(1-\varepsilon-\gamma)(1-p)+\gamma$$

The Choquet expected utility, computed with respect to this neo-additive capacity gives the following:

$$W_\nu(y)=(1-\varepsilon-\gamma)E_P(u(y)-X(\omega))+\varepsilon \inf_{\omega\in\Omega}(u(y)-X(\omega))+\gamma \sup_{\omega\in\Omega}(u(y)-X(\omega))$$

Appendix B: Proof of Proposition 2

From (4) and (5),

$$\left.\frac{\partial\lambda^{**}}{\partial Y}\right|_{d\beta=0}=-\frac{1}{D''_{\lambda\lambda}}\left.\frac{\partial D'_\lambda}{\partial Y}\right|_{d\beta=0} \quad \text{and} \quad \left.\frac{\partial\lambda^{**}}{\partial y_i}\right|_{dY=0}=-\frac{1}{YD''_{\lambda\lambda}}\left.\frac{\partial D'_\lambda}{\partial\beta_i}\right|_{dY=0}$$

where $D''_{\lambda\lambda}<0$ from the second order condition of the optimization program.

(i) From (5) and $\beta_i=\frac{y_i}{Y}$, we have $D'_\lambda=\sum_{i=1}^k\alpha_i n_i[-T'(\lambda)\beta_i u'(\beta_i(Y-T(\lambda)))+p(1-\delta_i)V]$, so that:

$$\left.\frac{\partial D'_\lambda}{\partial Y}\right|_{d\beta=0}=-T'(\lambda)\sum_{i=1}^k\alpha_i n_i\beta_i^2u''(\beta_i[Y-T(\lambda)])>0 \quad \text{and thus} \quad \left.\frac{\partial\lambda^{**}}{\partial Y}\right|_{d\beta=0}>0$$

(ii) If $R=1$, $\frac{\partial\lambda^{**}}{\partial y_i}|_{dY=0}=0$ because, from (7), λ^{**} depends only on Y.

If $R\neq 1$, for Y given and y_l given for $l\neq i$ and $l\neq j$, we have $n_iy_i+n_jy_j=K$, where K is a constant

$$\begin{aligned}
D'(\lambda)=&-\frac{T'(\lambda)}{Y}\left(1-\frac{T(\lambda)}{Y}\right)^{-R}\\
&\times\left[\sum_{l\neq i\,,\,l\neq j}\alpha_l n_l y_l^{1-R}+\alpha_i n_i y_i^{1-R}+\alpha_j n_j\left(\frac{K-n_iy_i}{n_j}\right)^{1-R}\right]\\
&+\sum_{l=1}^k\alpha_l n_l p(1-\delta_l)V
\end{aligned}$$

$$\begin{aligned}
\left.\frac{\partial\lambda^{**}}{\partial y_i}\right|_{\substack{dY=0,\,dy_l=0,\\ l\neq i,\,l\neq j}}&=-\frac{T'(\lambda)}{Y}\left(1-\frac{T(\lambda)}{Y}\right)^{-R}\\
&\quad\times\left[(1-R)\alpha_i n_i y_i^{-R}-(1-R)\alpha_j n_j\left(\frac{K-n_iy_i}{n_j}\right)^{-R}\frac{n_i}{n_j}\right]\\
&=-\frac{T'(\lambda)}{Y}\left(1-\frac{T(\lambda)}{Y}\right)^{-R}(1-R)\left(\frac{\alpha_i}{y_i^R}-\frac{\alpha_j}{y_j^R}\right)n_i
\end{aligned}$$

which has the sign of $(R-1)(\frac{\alpha_i}{y_i^R}-\frac{\alpha_j}{y_j^R})$.

Appendix C: Proof of Proposition 4

(i) λ^{**} is solution of (4). Let $e_j = (0; \ldots; 0; 1; 0; \ldots; 0)$, with 1 uniquely at the jth place. Then $\lambda^*(\delta_j, y_j)$ is solution of (4) when $(\alpha_1, \ldots, \alpha_k) = e_j$. We set:

$$H(\alpha_1, \ldots, \alpha_k, \lambda) = \sum_{i=1}^{k} \alpha_i n_i \left[-T'(\lambda) \frac{y_i}{Y} u'\left(y_i \left(1 - \frac{T(\lambda)}{Y} \right) \right) + p(1-\delta_i)V \right]$$

We have $H(\alpha_1, \ldots, \alpha_k, \lambda^{**}) = 0$, and $H(e_j, \lambda^*(\delta_j, y_j)) = 0$ for any j.

Let j_1, j_2 defined by $H(e_{j_1}, \lambda^{**}) = \min_j H(e_j, \lambda^{**})$ and $H(e_{j_2}, \lambda^{**}) = \max_j H(e_j, \lambda^{**})$.

We have $H(\alpha_1, \ldots, \alpha_k, \lambda) = \sum_{j=1}^{k} \alpha_j H(e_j, \lambda)$. Since $H(\alpha_1, \ldots, \alpha_k, \lambda^{**}) = 0$, thus $H(e_{j_1}, \lambda^{**}) < 0 < H(e_{j_2}, \lambda^{**})$.

We can note that $H(e_{j_1}, \lambda)$ is decreasing in λ (since the second order condition of program (4) is satisfied) and $H(e_{j_1}, \lambda^{**}) < 0 = H(e_{j_1}, \lambda^*(\delta_{j_1}, y_{j_1}))$. Thus, $\lambda^{**} > \lambda^*(\delta_{j_1}, y_{j_1})$. The same reasoning allows to prove that $\lambda^{**} < \lambda^*(\delta_{j_2}, y_{j_2})$.

(ii) For CRRA utility functions, for any $R > 0$, $\lambda^{**} < \lambda^*(\delta_i, y_i) \Leftrightarrow \frac{\partial D'_\lambda}{\partial \alpha_i} > 0$ according to Proposition 3 and its proof, where $\frac{\partial D'_\lambda}{\partial \alpha_i} = n_i(\frac{-y_i T'(\lambda^{**})}{Y} u'(y_i[1 - \frac{T(\lambda^{**})}{Y}]) + (1-\delta_i)pV)$.

For $R = 1$,

$$\frac{\partial D'_\lambda}{\partial \alpha_i} = n_i \left(-\frac{T'(\lambda^{**})}{Y - T(\lambda^{**})} + (1-\delta_i)pV \right) = n_i[-(1-\overline{\delta})pV + (1-\delta_i)pV]$$

from (7) and thus $\frac{\partial D'_\lambda}{\partial \alpha_i} = n_i pV(\overline{\delta} - \delta_i)$ i.e., $\lambda^{**} < \lambda^*(\delta_i, y_i) \Leftrightarrow \overline{\delta} > \delta_i$. Similarly, we have $\lambda^{**} = \lambda^*(\delta_i, y_i) \Leftrightarrow \overline{\delta} = \delta_i$ and thus $\lambda^{**} = \lambda^*(\overline{\delta}, \bar{y})$.

For $R \neq 1$,

$$\begin{aligned}\frac{\partial D'_\lambda}{\partial \alpha_i} &= n_i \left[-\frac{T'(\lambda^{**})}{Y} \left(1 - \frac{T(\lambda^{**})}{Y} \right)^{1-R} y_i^{1-R} + (1-\delta_i)pV \right] \\ &= n_i \left[-y_i^{1-R} pV(1-\overline{\delta}) \frac{\sum_{j=1}^{k} \alpha_j n_j}{\sum_{j=1}^{k} \alpha_j n_j y_j^{1-R}} + (1-\delta_i)pV \right]\end{aligned}$$

from (4) and (5).

Then, $\frac{\partial D'_\lambda}{\partial \alpha_i} = n_i pV[-\frac{u(y_i)}{\bar{u}(y_1,\ldots,y_k)}(1-\overline{\delta}) + (1-\delta_i)]$ and thus $\lambda^{**} < \lambda^*(\delta_i, y_i) \Leftrightarrow \frac{u(y_i)}{\bar{u}(y_1,\ldots,y_k)} < \frac{1-\delta_i}{1-\overline{\delta}}$.

Consequently, for $R \neq 1$, $\lambda^{**} < \lambda^*(\overline{\delta}, \bar{y}) \Leftrightarrow \frac{u(\bar{y})}{\bar{u}(y_1,\ldots,y_k)} < 1$.

Note that, for $R > 1$ this means that $u(\bar{y}) > \bar{u}(y_1, \ldots, y_k)$ i.e., that $u(\bar{y}) > \frac{\sum_{j=1}^{k} \alpha_j n_j u(y_j)}{\sum_{j=1}^{k} \alpha_j n_j}$. This last inequality is true for any u concave. Then $\lambda^{**} < \lambda^*(\overline{\delta}, \bar{y})$ for $R > 1$.

Moreover, for $R < 1$, $\frac{u(\bar{y})}{\bar{u}(y_1,\ldots,y_k)} < 1 \Leftrightarrow u(\bar{y}) < \frac{\sum_{j=1}^{k} \alpha_j n_j u(y_j)}{\sum_{j=1}^{k} \alpha_j n_j}$ which is never true for u concave. Then $\lambda^{**} > \lambda^*(\overline{\delta}, \bar{y})$ for $R < 1$.

(iii) Assume $y_i = y$, $\forall i$. In this case, the first order condition (6) becomes

$$\frac{y}{Y} T'(\lambda) u'\left(y \left[1 - \frac{T(\lambda)}{Y} \right] \right) = pV(1-\overline{\delta})$$

and we obtain the first order condition (3) of the program giving the risk level preferred by an individual of trust level $\overline{\delta}$, which implies $\lambda^{**} = \lambda^*(\overline{\delta}, y)$.

Appendix D: Proof of Proposition 5

λ^{**} is solution of $D'(\lambda)=0$ with

$$D'(\lambda)=\sum_{i=1}^{k}\alpha\delta_i^c n_i\left[-T'(\lambda)\frac{y}{Y}u'\left(y\left(1-\frac{T(\lambda)}{Y}\right)\right)+p(1-\delta_i)V\right]$$

Consequently, $\frac{d\lambda^{**}}{dc}=-\frac{D''_{\lambda c}}{D''_{\lambda\lambda}}$ with $D''_{\lambda\lambda}<0$ from the second order condition of the optimization program. Then, the sign of $\frac{d\lambda^{**}}{dc}$ is the same as the sign of $D''_{\lambda c}$

$$D''_{\lambda c}=\alpha\sum_{i=1}^{k}(\ln\delta_i)\delta_i^c n_i\left[-T'(\lambda)\frac{y}{Y}u'\left(y\left(1-\frac{T(\lambda)}{Y}\right)\right)+p(1-\delta_i)V\right]$$

we set $F_i=-T'(\lambda)\frac{y}{Y}u'(y(1-\frac{T(\lambda)}{Y}))+p(1-\delta_i)V$.

There exists $j\in\{1;\dots;k\}$, such that $F_i\geq 0\Leftrightarrow i\leq j$. Let $a_i=-\ln(\delta_i)$, thus $(a_i)_{1\leq i\leq k}$ is a positive decreasing sequence

$$\begin{aligned}-D''_{\lambda c}&=\alpha\sum_{i=1}^{k}a_i\delta_i^c n_i F_i=\alpha\sum_{i\leq j}a_i\delta_i^c n_i F_i+\alpha\sum_{i>j}a_i\delta_i^c n_i F_i\\&\geq a_j\alpha\sum_{i\leq j}\delta_i^c n_i F_i+a_{j+1}\alpha\sum_{i>j}\delta_i^c n_i F_i\geq a_{j+1}\alpha\sum_{i=1}^{k}\delta_i^c n_i F_i=a_{j+1}D'(\lambda)=0\end{aligned}$$

Appendix E: Proof of Proposition 6

Proof of (i) The reduction is preferred to authorization iff $W_{author}(\varepsilon_i,Q_i)\leq W_{red}(\varepsilon_i,Q_i)$, which is equivalent to $u(y)-\varepsilon_i b-Q_i\leq u(y(1-t))-\varepsilon_i b-(1-\lambda)Q_i$, where $Q_i=p_iV_i(1-\delta_i)$, i.e.,

$$W_{author}(\varepsilon_i,Q_i)\leq W_{red}(\varepsilon_i,Q_i)\iff\lambda Q_i\geq u(y)-u(y(1-t))\tag{9}$$

Prohibition is preferred to authorization iff $W_{author}(\varepsilon_i,Q_i)\leq W_{prohib}(\varepsilon_i,Q_i)$, which is equivalent to $u(y)-\varepsilon_i b-Q_i\leq u(y(1-\theta))$, i.e.,

$$W_{author}(\varepsilon_i,Q_i)\leq W_{prohib}(\varepsilon_i,Q_i)\iff Q_i\geq u(y)-u(y(1-\theta))-\varepsilon_i b\tag{10}$$

Prohibition is preferred to reduction iff $W_{red}(\varepsilon_i,Q_i)\leq W_{prohib}(\varepsilon_i,Q_i)$, which is equivalent to $u(y(1-t))-\varepsilon_i b-(1-\lambda)Q_i\leq u(y(1-\theta))$, i.e.,

$$W_{red}(\varepsilon_i,Q_i)\leq W_{prohib}(\varepsilon_i,Q_i)\iff(1-\lambda)Q_i\geq u(y(1-t))-u(y(1-\theta))-\varepsilon_i b\tag{11}$$

These 3 inequalities are equivalent to (8), where we have:

$$C_3=\frac{u(y)-u(y(1-t))}{\lambda}$$

$$B_2=\frac{u(y)-u(y(1-\theta))}{b}\quad\text{and}\quad C_2=u(y)-u(y(1-\theta))$$

$$B_1 = \frac{u(y(1-t)) - u(y(1-\theta))}{b} \quad \text{and} \quad C_1 = \frac{u(y(1-t)) - u(y(1-\theta))}{1-\lambda}$$

Those 5 parameters are clearly all positive. □

Proof of (ii) *and* (iii)

$$(\varepsilon_i, Q_i) \in E_2 \iff (W_{red}(\varepsilon_i, Q_i) \geq W_{author}(\varepsilon_i, Q_i) \quad \text{and} \quad W_{red}(\varepsilon_i, Q_i) \geq W_{prohib}(\varepsilon_i, Q_i))$$

i.e.,

$$(\varepsilon_i, Q_i) \in E_2 \iff \left(C_3 \leq Q_i \leq C_1\left(1 - \frac{\varepsilon_i}{B_1}\right)\right)$$

thus

- if $C_1 < C_3$, then $E_2 = \emptyset$,
- if $C_1 \geq C_3$, then $(\varepsilon_i, Q_i) \in E_2$ is possible for $Q_i \in [C_3, C_1]$ and ε_i sufficiently low.

We want now to draw the 2 figures. Let $\Delta = \{(\varepsilon_i, Q_i); Q_i \in [0; +\infty[, \varepsilon_i \in [0; 1]\}$.

The domain Δ can be split in 3 zones: $\Delta = E_1 \cup E_2 \cup E_3$. From the inequalities (8), we can easily see that E_1, E_2 and E_3 are convex sets. However, the union of two of these zones is not necessarily a convex set.

We note that for ε_i and Q_i near 0, the inequalities in (8) are not satisfied. (ε_i, Q_i) is then in the zone E_1. An agent with loss expectation Q_i low is thus always in favor of authorization, if she trusts the government (i.e., ε_i near 0).

Conversely, if Q_i and ε_i are high, then the agent is in favor of prohibition, because the risk Q_i is high, and the trust is low.

Between these two extreme cases, authorization, reduction and prohibition are possible. □

Appendix F: Proof of Proposition 8

(i) We set

$$D_z = \sum_{i=1}^{k} n_i \alpha_i W_z(\varepsilon_i, Q_i)$$

where $z = 1$ refers to authorization, $z = 2$ to reduction and $z = 3$ to prohibition.

The policy z^{**} is adopted iff $D_{z^{**}} = \max(D_1, D_2, D_3)$. We have

$$\begin{aligned} D_1 &= \sum_{i=1}^{k} n_i \alpha_i [u(y) - \varepsilon_i b - Q_i] \\ &= \sum_{i=1}^{k} n_i \alpha_i u(y) - \sum_{i=1}^{k} n_i \alpha_i \varepsilon_i b - \sum_{i=1}^{k} n_i \alpha_i Q_i \\ &= W_{author}(\overline{\varepsilon}, \overline{Q}) \sum_{i=1}^{k} n_i \alpha_i \end{aligned}$$

setting $\overline{\varepsilon} = \frac{\sum_{i=1}^{k} n_i \alpha_i \varepsilon_i}{\sum_{i=1}^{k} n_i \alpha_i}$ and $\overline{Q} = \frac{\sum_{i=1}^{k} n_i \alpha_i Q_i}{\sum_{i=1}^{k} n_i \alpha_i}$.

We can similarly check that

$$D_2 = \sum_{i=1}^{k} n_i \alpha_i W_{red}(\overline{\varepsilon}, \overline{Q}) \quad \text{and} \quad D_3 = \sum_{i=1}^{k} n_i \alpha_i W_{prohib}(\overline{\varepsilon}, \overline{Q})$$

This implies that the political decision corresponds to the preference of an "average" agent, i.e., of characteristics $(\overline{\varepsilon}, \overline{Q})$, where $\overline{\varepsilon}$ and $\overline{Q}$ are the averages of the ε_i and the Q_i, computed with the political weight α_i of each agent.

Authorization is then adopted iff $(\overline{\varepsilon}, \overline{Q}) \in E_1$, reduction of risk if $(\overline{\varepsilon}, \overline{Q}) \in E_2$, and prohibition $(\overline{\varepsilon}, \overline{Q}) \in E_3$. The point $(\overline{\varepsilon}, \overline{Q})$ is in the convex hull of the points (ε_i, Q_i), for $i = 1, \dots, k$.

(ii) Since E_1, E_2, E_3 are clearly convex sets, we find that if all the groups have the same preferred policy (i.e., belong to the same E_s), then the policy chosen will be this one.

(iii) In Case 1, according to Proposition 6(ii), only two decisions can be preferred: authorization and prohibition.

Proposition 8(iii) is then due to the convexity of the sets E_1 and E_3:

- if $(\varepsilon_i, Q_i) \in E_s$, for $i = 1, \dots, k$, with s given, $s = 1$ or $s = 3$, then $(\overline{\varepsilon}, \overline{Q}) \in E_s$,
- else obviously $z^{**} \in \{z^*(\varepsilon_i, Q_i), i = 1, \dots, k\}$, since $\{z^*(\varepsilon_i, Q_i), i = 1, \dots, k\} = \Delta$.

(iv) In Case 2, E_2 is not empty and $E_1 \cup E_2$, $E_2 \cup E_3$ and $E_1 \cup E_3$ are clearly not convex sets and then even if $(\overline{\varepsilon}, \overline{Q}) \in \text{conv}\{(\varepsilon_i, Q_i), i = 1, \dots, k\}$, we may have $z^*(\overline{\varepsilon}, \overline{Q}) \notin \text{conv}\{z^*(\varepsilon_i, Q_i), i = 1, \dots, k\}$.

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