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Confrontation between shareholders and local residents over safety investments in high-risk industries

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ABSTRACT

The aim of this article is to model a negotiation between shareholders in high-technology-risk industries and local residents on the safety investments to be implemented. The methodology used is a Nash bargaining model, with a DE curve representing shareholders' dividend demands and an NS curve representing the safety demands of local residents' associations. The model is used to determine the level of safety investment required. One of the main results is that the estimation of a higher accident risk is accompanied by both a higher safety investment and a higher dividend payout. The most obvious implication of this result is that it is undoubtedly necessary to give greater weight to local residents in investment decision-making, in order to improve the well-being of all stakeholders.

KEYWORDS

Consultation; high-risk industries; safety investments; accident probability

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1. Introduction

Over the last 30 years, the topic of major technological risks has been the subject of a transformation in the forms of state intervention, as well as in the modes of citizen participation.

During this period, public regulations were built around the idea of obliging so-called Seveso companies to produce and disseminate information on the risks to which people living near hazardous facilities may be exposed.

However, the AZF disaster in Toulouse in 2001 prompted the French government to restructure its major hazard prevention policy. This led to the creation of Site Monitoring Commissions (SMC) and Technological Risk Prevention Plans (PPRT) under the Bachelot law.[1] PPRTs aim to redirect urban development by taking hazard zones into account, while SMCs institutionalize public consultation on the subject of major technological risks.

SMCs therefore provide a forum for public consultation on the conditions for maintaining a hazardous facility in an urbanized area. Around 500 CLICs have been set up, with each committee corresponding to the existence of a so-called Seveso plant in an urban area. The permanent secretariats for the prevention of industrial pollution set up thirty years earlier had been used to experiment with the principle of consultation. But one of the innovations brought about by the creation of SMCs, as Suraud (2013) points out, is "the possibility for SMC members to have access to industrial files and, more specifically, to the hazard studies produced by the company". Hazard studies, carried out by manufacturers and validated by the public administration, present the sources of danger, the areas potentially impacted and the prevention measures adopted.

One of the most important aspects of consultation concerns investments in plant safety (Suraud, 2013). The aim of consultation is clear: to inform citizens and take their views into account, in order to reduce risks and thus their contestability. The aim of this article is to formalize one aspect of concertation, namely the implementation of safety investments. We define concertation/negotiation in terms of industrialists taking into account the interests of local residents when deciding to invest in safety.

Existing work in the social sciences shows that the implementation of citizen debates enables the demands of civil society to be integrated into the decisions of companies and the state. For some sociologists, SMCs as organized today would therefore be a significant step forward for the local population in influencing risk prevention policies (Revel et al., 2007; Bourg et al., 2005; Reber, 2011).

Nevertheless, the asymmetrical nature of the relationship between local residents and high-risk industries has been highlighted by some sociologists and economists (Piluso, 2013, Luhman N., 1993, Godard, 1993, Spangler M.B, 1982). Magali Nonjon (2009), studying the actual conduct of consultation within CLICs, points out that "local residents are thus only invited to assume the status of complainants around very factual claims. The legitimacy of proximity condemns them to the position of mere receivers of information, and annihilates any desire for debate".

As Zwarterook (2013) summarizes: "The introduction of the notion of concertation brings about significant changes in the approach to the 'public': we break with a habitual and still widespread image of the public as mainly subject to worries, fears, perceptions; we recognize the public as a possible interlocutor, other than, therefore, as a mere recipient of information messages and communication campaigns; we acknowledge that risks, as problems, can and must be the subject of discussions or even confrontations between "stakeholders", in the positive sense of the term. However, consultation on industrial risks raises a number of questions, and CLICs are sometimes called into question, as they are considered insufficient because they leave too little room for citizen expression.

The aim of our research is twofold: firstly, to provide a theoretical basis for the two-fold observation we have

[1] Law of July 31, 2003 on major technological and natural risks.

just made: progress in the process of integrating the citizen's point of view, but notable shortcomings in the practice of negotiation; secondly, to show that a deepening of consultation (in the sense of taking greater account of the citizen's point of view) is not necessarily contrary to the interests of the firm's shareholder-owners.

The article by Piluso (2016) shows that a safety investment surplus is compatible with higher expected profit. In the present work, we would like to go a step further and show that a safety investment surplus can be accompanied by a higher effective dividend payout.

Our analysis will confirm that current consultation conditions are not optimal from the point of view of local residents. While the inclusion of their demands makes it possible to reduce the volume of safety investments implemented, it will become apparent that the shortcomings of the consultation process are linked to the fact that citizens are deprived of some of the key variables in the dialogue, which have a decisive influence on the scale of safety investments.

Our analysis uses the Nash bargaining model (Binmore, Rubinstein and Wolinsky, 1986), based on the theory of cooperative games. The quantity to be maximized corresponds to the product of the gains that each party manages to obtain in the event of agreement, weighted by the weight of each agent in the negotiation. This model has had a number of applications, notably in the field of labor economics (Layard, Nickell and Jackman, 1991).

The first section describes the structure of the negotiation model adopted. In a second section, the main results of the analysis will be highlighted.

2. A model for negotiating security investments

Three types of stakeholder are analyzed: the company manager (1.1), shareholders (1.2) and a local residents' association. Local residents are consulted to decide on the level of safety investment implemented by the firm (1.4).

Four simplifying assumptions characterize the model:

Assumption 1. The manager seeks to maximize the firm's net profit. His objective is therefore the firm's growth.

Assumption 2. The firm's debt ratio is zero. It is assumed that it self-finances its investments.

Assumption 3. In practice, firms reduce the randomness of their economic results by spending on self-protection (as defined by Ehrlich and Becker, 1972), self-insurance and insurance. Prevention expenditure comprises all the resources deployed to reduce the probability of an accident (self-protection), as well as those deployed to limit damage in the event of a risk occurring (self-insurance). Safety investments cover all aspects of prevention (self-protection and self-insurance). They may, for example, be aimed at making production technology less dangerous, but also at protecting employees and local residents in the event of a risk occurring. However, to simplify the model, we will assume that the firm does not enter into a contract with an insurance company, and that investment in safety only affects the probability of an accident.

Assumption 4. Social science literature shows that local residents perceive a danger, while companies and shareholders perceive a risk. According to sociologists, there is an asymmetry of perception between industrialists and local residents, in other words, between those who produce the risk and those who are involuntarily exposed to it: the former carry out a Cost-Benefit calculation of the installations on the basis of probabilities of occurrence, while local residents perceive only the danger represented by the existence of these facilities independently of any probability of occurrence (Chaskiel, 2008). To shed some light on this analysis, it should be remembered that a company frequently has the opportunity to pool the risks of several sites (which, in some cases, reduces the overall risk). In this respect, it can be considered risk-neutral. On the other hand, local residents are often unable to make use of this type of pooling, and are critical of the threat (or potential loss) associated with the facility. Particularly with regard to the "long term" threat, they are concerned about its diffuse nature and its potential to affect future generations. In the shorter term, from a material point of view, local residents fear the threat to their homes, most often acquired over the long term. We can therefore assume that they want to ward off this threat by influencing the implementation of prevention policies by industrialists.

Now that the simplifying assumptions have been made, we can define the model equations.

2.1. Modeling firm behavior

The net savings π of the firm investing in safety is defined in accounting terms by:

$$\pi = P - \delta K - DIV - S$$

with P the firm's gross profit, DIV the amount of dividends distributed to shareholders and S the amount of securitization investment during the period under consideration. K is the total productive capital accumulated in the period under consideration. δ is its rate of decay.

Dividing net savings π by the total capital stock gives the following relationship:

$$\frac{\pi}{K} = g - div - s$$

Div and s correspond respectively to the dividend distributed per unit of productive capital and the amount of security investment per unit of capital. The economic rate of return g depends on a distribution parameter α including the markup, the wage-profit split and indirect taxes. It also depends on average capital productivity (Y/K):

$$g = [\alpha(Y/K)] - \partial$$

It is assumed that g is a model parameter.

The firm carries out a productive activity that involves risk: this activity is likely to result in an accident. From a strictly economic point of view, this accident alters the firm's profitability (Barro R.J., 2006).

Specifying an accident probability function is particularly tricky. The latter is most often the result of empirical studies on frequencies of occurrence, which are exogenous (Levêque F., 2013, Gollier C., 2007). Moreover, it can be modified according to the experts commissioned (ICSI, 2009). In other words, by definition, there is no microeconomic basis for establishing such a function.

We therefore choose a simple accident probability function$\varphi(s)$ which decreases with the safety investment rate:

$$\varphi(s) = e^{-as}$$

The parameter a represents the degree of effectiveness of the safety investment, or, equivalently, the degree of danger posed by the installation once the investment has been made. As a increases, the same rate of safety investment generates a lower probability (1) of accident. The higher the parameter, the more effective the investment, or, to put it another way, the less dangerous the plant will be. This parameter is estimated by the company's in-house experts (ICSI, 2009) and is made public in the report setting out the hazard study.

The manager's objective being, by hypothesis, the growth of the firm, he seeks to maximize the net profit per unit of capital achievable in the absence of accidents, i.e.:

$$\omega = (g - div - s)(1 - e^{-as}) \tag{1}$$

To sum up, the main variables characterizing the firm's behavior are the dividend paid to shareholders div, the safety investment implemented s, and the probability of an accident, which depends on the degree of efficiency of the safety investment. By hypothesis, the firm seeks to maximize its expected net profit.

2.2. Modeling shareholder behavior

It is assumed that the shareholder has a minimum acceptable dividend requirement. The determinants of this minimum acceptable dividend are defined by the Capital Asset Pricing Model (CAPM). They are at least partly external to the present model. To simplify calculations, this dividend requirement from shareholders is assumed to be exogenous.[2] We therefore assume:

$$div = \overline{div}\ (DE) \tag{2}$$

(DE) is the straight line representing the unit dividend demanded by shareholders.

So, for shareholders, only one variable is taken into account when modeling their behavior: the minimum acceptable dividend.

2.3. Modeling the behavior of the local residents' association

The aim of the local residents' association is to minimize the risk of accidents associated with the company's production activities. It derives its well-being from the scale of the safety investments made. It will therefore be assumed to have a standard utility function U, the argument of which is the amount of safety investment per unit of capital invested:

$$U = as^{\beta}\ with\ \beta < 1\ and\ a > 0 \tag{3}$$

β measures the elasticity of utility with respect to the rate of security investment, while a remains the efficiency parameter of this investment, measured by experts employed by the firm.

This utility function has the usual properties, namely:

$$\frac{\partial U}{\partial s} = \beta\ as^{\beta-1} > 0\ and\ \frac{\partial U^2}{\partial^2 s} = \beta(\beta-1)as^{\beta-2} < 0 \tag{4}$$

Modeling the behavior of local residents thus relies on two important variables: the safety investment made by the firm, and the degree of efficiency of that investment. These two variables directly determine the utility or well-being of local residents.

2.4. Negotiation modeling

Negotiation between firms and local residents is represented in this article by a Nash bargaining model.

The Nash criterion consists in maximizing the gains obtained by each party in the event of agreement, weighted by their respective weight in the negotiation.

The institutional framework of bargaining guides the choice of modeling based on the theory of cooperative games. In the LINC framework, stakeholders considered to be rational are invited to communicate with each other to reach a "contract" on the best solution for the community as a whole. This institutional framework corresponds to the theoretical framework of cooperative games: the latter presuppose, on the one hand, the rationality of agents, and on the other, communication between players to define a collective solution (Cahuc, Zylberberg, 1996). In this type of game, players win or lose together. Thus, if negotiation fails, local residents are likely to leave the area or engage in conflict (with the costs that this entails for both the residents and the firm). If the negotiation

[2] The endogenization of the dividend expected by the shareholder poses insurmountable problems for the analytical resolution of the model.

succeeds, the level of security decided upon benefits both stakeholders: the firm can continue to operate, benefiting from the positive externalities of the area in which it is located, and the fears of local residents are allayed. In line with the principles of this approach, we assume that the contract signed between the players is "stable" in the sense that one of the two stakeholders has no incentive to modify the contract by forming a different coalition.[3]

The common objective to be pursued through consultation is the reduction of technological risks.

The firm's gain is represented by the product of its net savings and the probability of no accident $(g - div - s)(1 - e^{-as})$. The gain for the local residents' association is represented by the utility it derives from the safety investment $(as)^{\beta}$. Negotiating the level of safety investment to be implemented can therefore involve solving the problem:

$$Max\theta = (g - div - s)^{\gamma}(1 - e^{-as})^{\gamma}(as)^{\beta(1-\gamma)}, s \geq 0 \tag{5}$$

with γ the weight of the firm in the negotiation and $1 - \gamma$ that of the local residents' association. To simplify the resolution of the program, we rewrite it as follows:

$$Max\theta = \gamma\, ln(\, g - div - s) + \gamma\, ln(\, 1 - e^{-as}) + \beta(1 - \gamma)\, ln(\, as), s \geq 0 \tag{6}$$

The first-order condition gives:

$$\frac{\gamma a}{e^{as} - 1} + \frac{\gamma}{div - g + s} + \frac{\beta - \beta\gamma}{s} = 0 \tag{7}$$

hence:

$$[3]\ div = \frac{\beta(\gamma - 1)(e^{as} - 1)(g - s) + s\gamma(a(s - g) + e^{as} - 1)}{\beta(\gamma - 1)(e^{as} - 1) - as\gamma} \tag{8}$$

with:

$$\frac{\partial div}{\partial s} = \frac{a\beta(\gamma - 1)(e^{as})(g - s) - \beta(\gamma - 1)(e^{as} - 1) + \gamma(a(s - g) + e^{as} - 1) + s\gamma(ae^{as} + a)}{\beta(\gamma - 1)(e^{as} - 1) - as\gamma} - \frac{(a\beta(\gamma - 1)e^{as} - a\gamma)(\beta(\gamma - 1)(e^{as} - 1)(g - s) + s\gamma(a(s - g) + e^{as} - 1)}{[\beta(\gamma - 1)(e^{as} - 1) - as\gamma]^2} < 0 \tag{9}$$

We therefore obtain a decreasing relationship between the unit dividend level and the safety investment rate. As the second derivative is negative, the function is also concave. We'll call this curve NS (negotiation/safety), representing the investment claimed by the local residents' association.

Relation (8) in this paragraph describes the set of unit dividend/security investment rate pairs that maximize the product of the gains resulting from consultation between the two stakeholders (NS curve for "negotiation/security"). Thus, the chosen security investment rate and the optimal distributed dividend lie at the point of intersection of the "DE" line and the "NS" curve. At this point, maximizing the gains from concerted action is compatible with the shareholder remuneration requirement.[4] It therefore satisfies the equation DE=NS:

[3] Nevertheless, there is a link between Nash's strategic approach to non-cooperative games and the institutional approach to cooperative games: when the delay between proposition statements tends to zero in Rubinstein's game, the solution of the latter converges to Nash's solution (Binmore, Rubinstein, Wolinsky, 1986).

[4] The dividend is not endogenous in equation 4. This is a relationship that links the dividend to the rate of safety investment, but at this stage of the model, neither of the 2 variables can be described as exogenous or endogenous. We need to fix one of the two variables (dividend) in order to know the other (security investment).

$$\overline{div} = \frac{\beta(\gamma-1)(e^{as}-1)(g-s) + s\gamma(a(s-g) + e^{as}-1)}{\beta(\gamma-1)(e^{as}-1) - as\gamma}(NS) \tag{10}$$

This can be plotted as follows, with the securitization investment rate on the x-axis and the dividend per unit distributed on the y-axis:

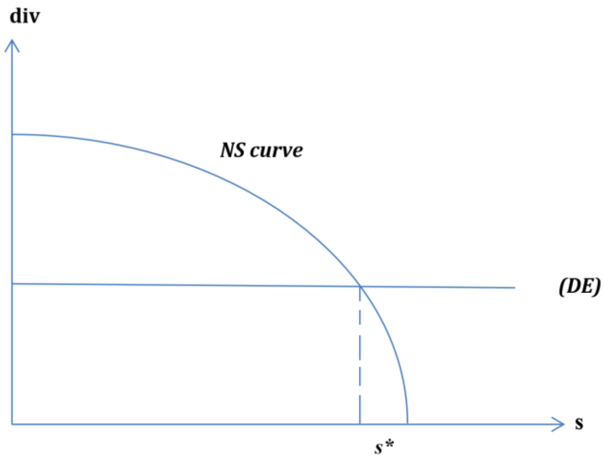

Figure 1. Determining the optimum safety investment.

To summarize, on the one hand we have the NS curve, which is the result of firm/shareholder negotiation on the level of safety investment to be implemented, and on the other the DE line, which represents the shareholders' dividend requirement. At the intersection of NS and DE, we obtain the optimal safety investment/dividend pair that enables the various players to maximize their objective function.

3. Lessons from the model

The model highlights two results.

The first, obvious one, is that taking into account the point of view of local residents in determining the safety investment rate constrains the firm. In the absence of concertation, and therefore in the absence of a NS curve, the firm is free to choose the safety investment that maximizes its net savings. The implementation of concertation forces firms to take into account the utility derived by local residents from the safety investment: they are no longer "free" to distribute the dividend desired by the shareholder. In the same way that union bargaining introduces downward rigidity into the real wage rate on the labour market, concertation leads to downward rigidity in the rate of safety investment.

The second result sheds new light on the real scope of consultation. It appears from the equilibrium equation (8) that one of the fundamental determinants of the level of safety investment is the efficiency parameter a of the investment rate, whatever the respective weight of each stakeholder in the negotiation.

Let's study the effect of a variation in parameter a on the NS curve.

The variation in a (here, the decrease) modifies the NS curve (passage from NS1 to NS2) by translating it to the right, so that the equilibrium investment rate increases (passage from s1 to s2). A decrease in parameter a (e.g. following a counter-examination) is symptomatic of a higher accident probability. The safety investment rate must increase to compensate for the increased risk and thus maintain the equilibrium of the consultation (see formal demonstration in the box).

However, such a shift also allows shareholders to increase their dividend requirement without lowering their security investment. In this way, the shift from DE1 to DE2, coupled with the shift from NS1 to NS2, enables a simultaneous increase in the unit dividend distributed and in the security investment (shift from s1 to s3).

In other words, the question we are asking is whether a double exogenous shock (on the parameters a and div) results in a rise or fall in the endogenous variable, unit safety investment. In the article, we show that if the probability of an accident increases, as does the unit dividend demanded by the shareholder, safety investment can increase (see formal demonstration in the box).

Thus, an increase in the rate of investment in safety is not incompatible with a greater distribution of dividends when the estimate of the probability of an accident changes: this is shown in Fig. 2, which represents the modification of the equilibrium following a negative shock to the parameter a. Insofar as this shock allows DE and PS to shift simultaneously, the interests of shareholders and local residents can therefore converge through concertation.

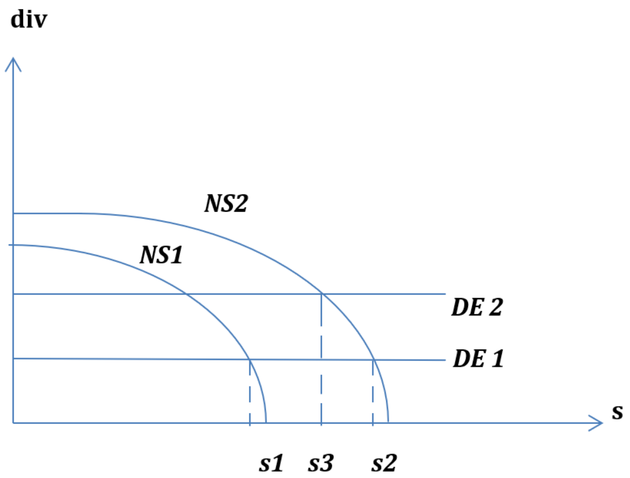

Figure 2. Simultaneous increase in optimal security investment and dividends paid to shareholders.

However, this key parameter of consultation is in the exclusive hands of the company: the experts who assess the risk are part of the company's internal departments (ICSI, 2009). The local residents' association is deprived of the main parameter influencing the outcome of the negotiation: it is obvious that the greater the estimated efficiency of each unit of investment, the less the firm will have to invest in safety.

Over and above any consideration of the weight of each stakeholder (and therefore of the value of the parameter γ), the consultation process would be fairer if the local residents' association had the option of commissioning its own expert to carry out the risk assessment. It could then compare its own a parameter with that announced by the company. As mentioned above, more equitable consultation and greater investment in safety do not necessarily mean lower dividends for shareholders: the model shows that consultation leads to higher dividends, even though the rate of investment in safety must increase.

Hazard studies are mandatory for all facilities classified for environmental protection (ICPE), and are examined by the public authorities. The latter have the option of commissioning a counter-expertise, but this is not systematic (ICSI, 2009). The thesis defended here is that opening up information on industrial safety to the public is insufficient as it stands: simple transparency (access to technical documents) or accompanied transparency (access to documents made available to the general public) are not enough to eliminate the asymmetry characteristic of consultation. It is the company and the public authorities who fundamentally hold the keys to negotiation by controlling the conduct of hazard studies. This is not a question of withholding information, but of scientific controversy: hazard studies are based on fragile data and are liable to be called into question. The confrontation of multiple viewpoints, along the lines of hybrid forums (Callon et al., 2001), is likely to increase the economic, social and environmental effectiveness of consultation.[5]

The main limitation of this result is that it depends on the functional form of the accident probability. Indeed, a varies both the level of probability (at a given level x) and the marginal efficiency of x. If accident probability takes an affine-type functional form, such as:

$$\phi(x) = a + \left(\frac{0.5}{x}\right) \tag{11}$$

with a < 0.5, then an increase in a (here, we must consider an increase) leads to a higher probability (at a given x) but does not influence the equilibrium x. It is therefore in fact a change in the marginal efficiency, not the overall efficiency, of safety investment that can lead to our result. The above conclusion holds only for certain technologies, where the marginal efficiency of the safety effort can be modified. If we extend the reasoning to technologies whose marginal safety efficiency cannot be modified, then deepening consultation via the possibility for citizens to commission a counter-expertise would not lead to any change in the firm's decision.

There's no doubt that the development of citizen consultation can be a vector for the development of a territory. According to Gay and Picard (2001), "the lived, organized territory, where power, strategy and trust can be expressed, offers an ideal configuration for the emergence of innovation activities by serving as a catalyst for the interactions that generate them. [...] Last but not least, the innovative capacity attached to the territory makes it a privileged instrument of endogenous development, which justifies its mobilization in public action". According to Blanchet and Paquiet (1999), local stakeholders can better control the environmental consequences of the economic activity of high-risk industries when they have a real capacity to influence. According to the same authors, they can even become the key component of a genuine development project. For Blanchet, Paquiet and Zampa (1996), "the presence of chemical industries is an asset that a conurbation must be able to capitalize on. To do this, we need to work ever more closely together to resolve conflicting environmental and risk issues". However, what we are trying to emphasize here is that the impact of more concerted action from the strict safety standpoint is likely to remain without effect.

It should be noted, however, that the probabilistic approach adopted within CSS and used for the model in this article does not deal with counteracting the consequences of improbable events.

Chaskiel (2008) and Piluso (2013) point out that when an industrial disaster like Fukushima occurs, local residents rally around the notion of danger. Danger can be defined in terms of the potential catastrophe to which local residents are exposed as a result of a decision by industrialists that is imposed on them. In this way, local residents reject probabilistic calculations and focus on assessing the potential damage that an industrial facility can cause. From this point of view, there is no justification for the existence of a hazardous facility, but the decision is the responsibility of industry and public authorities. The traditional distinction between risk and uncertainty is eclipsed by the distinction between risk (which is the approach of industrialists) and danger (which is the approach of local residents). In this context, Spangler (1982) points out that assessment criteria for hazardous industrial facilities are likely to diverge widely.

The probabilistic approach thus contributes to skewing the debate between specialists on the one hand, and

[5] To make our point more precise, we can quote Gaudilliere (2002), who comments on Callon's work: "These arenas are hybrid because they bring together actors we are not used to seeing in dialogue: engineers, association representatives, civil servants, researchers and industrialists - in other words, the whole range of groups interested in a given technical object. More fundamentally, these forums are hybrid because they call into question "delegative" democracy. For our authors, this is based on a rigid separation between political representatives and agents, coupled with an equally radical separation between scientists and laymen. This "double delegation" is fundamental and problematic, as it is at the root of the vast majority's inability to influence most of the decisions that affect our future. What is important about hybrid forums is that they offer a terrain for re-politicizing questions of science and technology, a terrain that allows ordinary people, non-professionals, to come and disrupt the classic mechanics of expertise" (*Ibid.*, p. 191).

between specialists and the general public on the other. When preparing hazard studies, the work of sorting out hazardous phenomena and selecting events likely to contribute to the sizing of safety investments is influenced by the traditional ALARP approach explained above. The most dangerous events, because they are highly improbable, are frequently excluded from hazard studies. Slow-kinetic accidents are also excluded, on the grounds that populations can be evacuated and thus spared (Martinais, 2010). The greater the number of eligible phenomena, the higher the estimated hazard level of the industrial facility. One way of improving consultation, and therefore safety, would be to involve local residents in discussions on eligible events. In this respect, our model shows that, if it leads to greater investment in safety, such an increase in consultation can be compatible with an increase in expected profit.

More generally, we can draw inspiration for ways of improving citizen consultation on technological risks from Beierle (1999), who proposes a list of socially desirable effects of taking the citizen's point of view into account: educating the public, incorporating public interests into the decision-making process, improving the quality of decisions, strengthening confidence in institutions, reducing conflict and, finally, justifying the time devoted to citizen participation. Webler, Tuler and Krueger (2001) emphasize the need to neutralize power asymmetries between actors, which is in line with our proposal to take into account the citizen's point of view by going beyond the limits imposed by the probabilistic approach. This point of view also echoes that of Viscusi (2000), who stresses that a probabilistic cost-benefit analysis may not be sufficient to adopt sufficiently protective measures: "Indeed, we want corporations to think about risks in a systematic manner and to undertake such calculations to ensure that there is appropriate risk balancing that is sufficiently protective. We all benefit when corporations have selected the right level of safety that is reflective of our own concern with safety and the costs of providing it. The merits of the analysis and the ultimate balance struck should be the main manner of concern, not whether undertaking a systematic analysis allegedly reflects a cold blooded attitude towards human life. Of course, the fact that companies have undertaken such balancing does not imply that they should be vindicated on economic grounds. Even armed with an extensive risk analysis, companies may fail to make sufficiently protective decisions. However, liability for corporate behavior should hinge on the risk and cost decisions, not on whether the firm undertook a risk analysis. We want to encourage corporations to do such systematic thinking about risk and cost" (Viscusi, 2000, p.4).

4. Conclusion

The NS DE model presented in this article describes the decision-making process of high-risk industries with regard to safety investments. It shows that, with the introduction of consultation bodies for the local population, companies are no longer free to choose between safety investments and shareholder dividends. The main finding of the article is that an increase in the estimated probability of an accident is not necessarily incompatible with the payment of higher dividends. The implication of this study is that it is necessary to put forward alternative ways of balancing the roles of different stakeholders (local residents, managers, shareholders), with, for example, the idea of allowing local residents to propose a counter-expertise. The sensitivity of the results of this study to the form taken by the probability of an accident means that it would be interesting to use different types of function in future research, and to see how negotiation, investment levels and dividend distribution are impacted.

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Conflict of interest

The author claims that the manuscript is completely original. The author declares no conflict of interest.

Appendix. Effect of a variation in parameter a on the NS curve and model equilibrium

Let's rewrite the first-order condition as follows:

$$\frac{\gamma}{div-g+s}=\frac{\gamma a}{e^{as}-1}++\frac{\beta(1-\gamma)}{s} \tag{12}$$

And let's put $\psi(s)=\frac{\gamma}{div-g+s}$ and $\phi_a(s)=\frac{\gamma a}{e^{as}-1}++\frac{\beta(1-\gamma)}{s}$

The function ψ is strictly increasing, continuous on [0 ; g-div [and tends to $+\infty$ in (g-div). Conversely, for any positive a, the function ϕ_a is strictly decreasing and continuous on] 0 ;g-div[and tends to $+\infty$ in 0.

Thus, by applying the Intermediate Value Theorem to ψ - ϕ_a, for example, which is strictly increasing, continuous, positive in the vicinity of (g-div) and negative in the vicinity of 0, we deduce that there is a single point $\overline{s}(a)$ in] 0 ; g-div[such that $=v(\overline{s}(a))\ \phi_a(\overline{s}(a))$.

Proposition i. For any$\mathrm{div}>0$, the function $\mathrm{a}\to\overline{\mathrm{s}}(\mathrm{a},\mathrm{div})$ is strictly decreasing, so that a decrease in a shifts the NS curve to the right.

Proposition ii. For all a>0, the function $\mathrm{div}\to\overline{\mathrm{s}}(\mathrm{a},\mathrm{div})$ is strictly decreasing.

Proposition iii. Let $\mathrm{a}_1,\mathrm{div}>0$ exist. There are η >0 and $\mathrm{a}_2<\mathrm{a}_1$ such that for any $\mathrm{div}\in[\mathrm{div}_1,\mathrm{div}_1+\eta]$ and any $\mathrm{a}<\mathrm{a}_2$, we have:

$$\overline{s}(a_1,div_1)<\overline{s}(a,div) \tag{13}$$

(the decrease in parameter a is accompanied by a simultaneous increase in s and div).

Proof. For (i), the function $x\to e^x$ is convex on R. So for any fixed v, the rate-of-change function $p(.,v)$ defined on $R-\{v\}$ by $u\to p(u,v)=\frac{e^u-e^v}{u-v}$ is an increasing function. With $v=0$, we deduce that $u\to\frac{e^u-1}{u}$ is increasing on R_+.

Thus, for any fixed $s,a\to\frac{a}{e^{as}-1}$ is decreasing on R_+ (division by s does not change the variation). We therefore deduce that for any fixed s, the function $a\to\phi_a(s)$ is strictly decreasing on R_+.

Let $a_1<a_2$. So for all positive $s\ \phi_{a2}(s)\le\phi_{a1}(s)$. Apply this inequality to $s=\overline{s}(a_1,div)$ and obtain:

$$\phi_{a2}\big(\overline{s}(a_1,div)\big)\le\phi_{a1}\big(\overline{s}(a_1,div)\big)=\psi\big(\overline{s}(a_1,div)\big) \tag{14}$$

Thus, by growing - $\psi\ \phi_{a2}$ and by its positive sign in $\overline{s}(a_1)$,we deduce that

$$\overline{s}(a_2,div)\le\overline{s}(a_1,div) \tag{15}$$

The proof is similar for point ii.

For point iii, equation (12) can be rewritten as:

$$F(s,a,div)=0 \tag{16}$$

Where $F(s,a,div)=\psi(s)-\varphi_a(s)$.

We have $\frac{\partial F}{\partial s}(a_1,div_1)\neq 0$, so by the theorem of implicit functions, the function $(a,div)\to\overline{s}(a,div)$ is C^I on $(R_+^*)^2$ and so we can do a limited development to order I:

$$\overline{s}(a_1 + h, div_1 + h) = \overline{s}(a_1, div_1) + h\frac{\partial \overline{s}}{\partial a} + k\frac{\partial \overline{s}}{\partial div} + o(h, k) \quad (17)$$

Partial derivatives are evaluated at (a_1, div_1).

Let's use the infinite norm $\|(h,k)\|_\infty = max(\,|h|, |k|)$.For all $\varepsilon > 0$, we have: there exists $\delta > 0$ such that for all h, k with $0 < \|(h,k)\|_\infty \leq \delta$, we have:

$$\left|\frac{\overline{s}(a_1 + h, div_1 + k) - \overline{s}(a_1, div_1)}{\|(h,k)\|_\infty} - (\frac{h}{\|(h,k)\|_\infty}\frac{\delta \overline{s}}{\partial a} + \frac{k}{\|(h,k)\|_\infty}\frac{\delta \overline{s}}{\partial div}\right| \leq \varepsilon \quad (18)$$

Let's take $h = -\delta < 0$ and $k > 0$ to be small enough that $-\frac{\delta \overline{s}}{\partial a} + \frac{k}{\|(h,k)\|_\infty}\frac{\delta \overline{s}}{\partial div} > -1/2\frac{\delta \overline{s}}{\partial a} > 0$. This is possible because we saw in (i) and (ii) that $\frac{\delta \overline{s}}{\partial a} < 0$ and $\frac{\delta \overline{s}}{\partial div} < 0$. With our previous choices of h and k, then $\varepsilon = 1/4\frac{\delta \overline{s}}{\partial a} > 0$, we obtain that:

$$\overline{s}(a_1 - \delta, div_1 + k) - \overline{s}(a_1, div_1) > 0 \quad (20)$$

This closes the proof with (i) and (ii).

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