

2000s-23

Environmental Risk Management and the Business Firm

Bernard Sinclair-Desgagné

Série Scientifique
Scientific Series



CIRANO
Centre interuniversitaire de recherche
en analyse des organisations

Montréal
Juillet 2000

CIRANO

Le CIRANO est un organisme sans but lucratif constitué en vertu de la Loi des compagnies du Québec. Le financement de son infrastructure et de ses activités de recherche provient des cotisations de ses organisations-membres, d'une subvention d'infrastructure du ministère de la Recherche, de la Science et de la Technologie, de même que des subventions et mandats obtenus par ses équipes de recherche.

CIRANO is a private non-profit organization incorporated under the Québec Companies Act. Its infrastructure and research activities are funded through fees paid by member organizations, an infrastructure grant from the Ministère de la Recherche, de la Science et de la Technologie, and grants and research mandates obtained by its research teams.

Les organisations-partenaires / The Partner Organizations

- École des Hautes Études Commerciales
- École Polytechnique
- Université Concordia
- Université de Montréal
- Université du Québec à Montréal
- Université Laval
- Université McGill
- MEQ
- MRST
- Alcan Aluminium Ltée
- AXA Canada
- Banque Nationale du Canada
- Banque Royale du Canada
- Bell Québec
- Bombardier
- Bourse de Montréal
- Développement des ressources humaines Canada (DRHC)
- Fédération des caisses populaires Desjardins de Montréal et de l'Ouest-du-Québec
- Hydro-Québec
- Imasco
- Industrie Canada
- Pratt & Whitney Canada Inc.
- Raymond Chabot Grant Thornton
- Ville de Montréal

© 2000 Bernard Sinclair-Desagné. Tous droits réservés. All rights reserved.

Reproduction partielle permise avec citation du document source, incluant la notice ©.

Short sections may be quoted without explicit permission, provided that full credit, including © notice, is given to the source.

Ce document est publié dans l'intention de rendre accessibles les résultats préliminaires de la recherche effectuée au CIRANO, afin de susciter des échanges et des suggestions. Les idées et les opinions émises sont sous l'unique responsabilité des auteurs, et ne représentent pas nécessairement les positions du CIRANO ou de ses partenaires.

This paper presents preliminary research carried out at CIRANO and aims at encouraging discussion and comment. The observations and viewpoints expressed are the sole responsibility of the authors. They do not necessarily represent positions of CIRANO or its partners.

Environmental Risk Management and the Business Firm^{*}

Bernard Sinclair-Desgagné[†]

Résumé / Abstract

Ce chapitre considère trois questions qui préoccupent de plus en plus les firmes dont les activités font peser certains risques sur la santé humaine et l'environnement, soit la révélation au public de ces risques, l'implication directe de parties externes (assureurs, banquiers, représentants du public, etc.) dans la gestion des opérations, voire la planification stratégique, et la gestion intégrée de tous les risques d'affaires. On résume les récentes percées de l'économie managériale sur ces sujets, et l'on indique certaines pistes de recherche particulièrement prometteuses.

This chapter considers three matters that business firms whose activities can be dangerous for human health and the environment increasingly have to deal with: public disclosure of all health and environmental risks, direct involvement of stakeholders in the management of operations, and integration of health and environmental risk management with the management of other business risks. It summarizes recent managerial economics research on those matters and suggests some promising research areas.

Mots Clés : Bilan environnemental, responsabilité étendue, gestion intégrée des risques

Keywords: Environmental risk disclosures, extended liability, integrated risk management

^{*} Corresponding Author: Bernard Sinclair-Desgagné, CIRANO, 2020 University Street, 25th floor, Montréal, Qc, Canada H3A 2A5 Tel.: (514) 985-4010 Fax: (514) 985-4039 email: desgagnb@cirano.umontreal.ca
A chapter for *The International Yearbook of Environmental and Resource Economics 2001/2002*, Tim Tietenberg and Henk Folmer, eds., Edward Elgar Publishing Inc. I wish to thank, without implicating, Henk Folmer, Landis Gabel, Olivier Godard, Kathleen Segerson and Tom Tietenberg for suggestions that improved significantly the structure and content of this chapter. I also acknowledge valuable conversations on many of the topics presented here with Narcisse Amon, Marcel Boyer, Estelle Gozlan, Patrick Lagadec, Robert Lapalme, Louis Lévy-Garboua, Erwann Michel-Kerjan, Marine de Montaignac and Carel Vachon. Finally, I am grateful to the Laboratoire d'économétrie de l'École polytechnique and to the Laboratoire d'économie industrielle, Paris, for their hospitality while I was writing this chapter.

[†] École Polytechnique de Montréal and CIRANO

1. Introduction

Regulation and management practices towards health and environmental risks are currently undergoing substantial adjustments. Pressure for change comes, on the one hand, from scientific and technological advances that may create new threats but that also open up new possibilities for mitigating the damages human activity often inflicts on nature. On the other hand, and perhaps more importantly, the current amendments respond to powerful socioeconomic forces that are reshaping the corporate landscape and the relationship between ordinary citizens, experts, business organizations and public institutions altogether. For instance, decisions based on risk assessments made by engineers and technicians have lost legitimacy in the eyes of lay people who are increasingly aware of the limitations of scientific knowledge; this accounts for a shift by regulatory authorities in favor of seeking public consent before launching new projects.¹ Another major trend stresses the empowerment of communities and their active involvement in taking care of their own safety; this entails that residents in the neighborhood of a noxious facility and their political representatives can now claim to have a stake in the operations of that facility. Current prospects of the new economy, finally, suggest a further increase of competitive pressure and of the volatility of markets.² Hence, the agenda of many corporate board meetings often includes topics and discussions centered on how the firm could cope simultaneously with all its business risks – old and new ones, short-term and long-term ones, financial and non-financial ones – in an efficient and systematic way.

This chapter's objective is to summarize, from the standpoint of the business firm, what appear to be the main regulatory and management issues in the actual context, and to point out some of the answers already or on the verge of being provided by economists. The presentation unfolds as follows. The upcoming section considers the matter of *disclosure* by firms of the health and environmental hazards induced by their activities. Risk regulators are increasingly using such an approach. I will briefly discuss some of the rationales for it, present some of the existing means to convey credible risk information to the public, and in particular look briefly at the actual debate concerning voluntary versus mandatory disclosures in the sphere of health and

¹ Of course, such consent will also be based in part on scientific evidence; but the latter will have to be brought through experts and processes acceptable to the public.

² The recent crises in Southeast Asia and Latin America constitute a clear example of how volatile the economy has become. For a lucid presentation of the various risks and challenges of the new economy, the interested reader may see, for instance, Meier (1998).

environmental risks. Section 3 considers the *active participation of risk bearers in the management of firms* that present health and environmental hazards. I will sketch the current regulatory background and draw attention on some relevant formal analyses. Section 4 examines regulatory and corporate demands for *an integrated approach to risk management*. I will summarize the objectives of this approach and consider three topics that seem essential for a successful implementation: leadership, communication and incentives. Section 5, finally, contains concluding remarks and sets an agenda for future research.

Before proceeding with the main text, I wish to warn the reader about my own biases and shortcomings. First, this survey chapter focuses mostly on the firm and puts relatively little weight on usual public economics issues such as the design of optimal regulation or the political economy of rule making. Second, it is the internal organization of the firm that occupies center stage rather than the organization of markets and competition issues. Third, the theoretical findings gathered and discussed in each section have a normative flavor rather than a positive one. Fourth, emphasis is put on theoretical rather than empirical work. Finally, I must apologize to the many authors whose contributions are omitted from the present list of references; by no means should this be interpreted as a personal judgment on the quality of their work.

2. Health and environmental risk disclosures

An approach to risk regulation that is becoming increasingly common is to “regulate through information,” that is to make accurate and up-to-date information about health and environmental risks publicly available. Examples of recent actions in this direction, some of which are described in the appendix to this chapter, include government-sponsored right-to-know programs on industrial toxic pollution, dissemination of environmental reports by several major corporations and industries, and securities regulations requiring disclosure of certain environmental liabilities and risks. New rules and standards are also currently being set for “green labels” and corporate environmental reporting.³ The first part of this section examines

³ An accurate description of current practice and the evolution of corporate environmental reporting is beyond the scope of this chapter. The interested reader may wish to see, for instance, Koehler and Chang (1999). It should be kept in mind, however, that a fundamental objective of rules and standards in this area is to achieve credibility in the eyes of the public.

some rationales for this approach. The main issues surrounding its implementation are discussed in 2.2.

2.1 *Some justifications*

Many arguments can play in favor or against public disclosure of health and environmental risks: some can be called cognitive, others are strictly economic, and others are finally based on ethics.

One first (cognitive) reason to spread information about risk is that this may *improve the quality of risk assessment*. Risk regulation comprises two main components: risk assessment and risk management. In practice, the former is traditionally assigned to a team of scientists and technicians. Their conclusions, however, are rarely uncontroversial. For the lack of data, the necessary extrapolations and judgmental assertions, the peculiar method chosen, and the fact that the scope of the analysis might have been limited a priori contribute altogether to set a significant margin of error (Pollak 1995). Moreover, extraneous estimates of potential damages (including the loss of human lives) often remain questionable, not only for ethical reasons, but also because any occurrence of an environmental catastrophe is likely to fuel public anger and to become a political event whose outcome is highly unpredictable (Sinclair-Desgagné and Vachon 2000). In this context it thus seems plausible that involving additional parties in the exercise of risk assessment could be useful, for the very reason that open criticism, challenge and discussion often yield better knowledge (particularly in science).⁴

This rationale for environmental risk disclosures can be related to a second, more political, one: risk disclosures might also be the only way to *implement the precautionary principle*. In its most popular version, which figures for instance in the Maastricht Treaty, the so-called “Precautionary principle” stipulates that “the absence of certainty, given our scientific knowledge, should not delay the use of measures preventing a risk of large and irreversible damages to the environment, at an acceptable cost.” This principle stresses an “act-then-learn” rather than a “learn-then-act” approach to risk. It underlies the European Union’s regulations concerning greenhouse gas emissions and many aspects of food safety.⁵ And it is likely to

⁴ Of course, this conclusion could be debated further. Tenants of quantitative risk assessments over qualitative ones might strongly challenge it, for instance, on the ground that involving more diverse stake-holders in risk assessment is likely to favor the latter.

⁵ A strict interpretation of the principle within the EC, which might actually not be free from the influence of lobby groups, has actually lead to a ban on imports of meat from hormone-raised cattle. This policy triggered a major trade

become more influential as innovation accelerates, generating more fears of unforeseen new hazards.⁶ In their recent paper Gollier, Jullien and Treich (2000) put forward an economic basis for the precautionary principle: it constitutes an appropriate rule when progress in risk assessment is expected and prudence is larger than twice absolute risk aversion.⁷ Hence, the principle could easily be misused without an understanding of risk attitudes and of the degree and nature of scientific uncertainty. This state of knowledge can only be achieved through open discussion concerning risk assessment procedures and results.

The latter further suggests that, in general, *prevention and deterrence of health and environmental risks might be more effective if risk bearers are directly involved*. In many situations, certainly, empowering private interested parties can also reduce substantially the administrative and enforcement costs of regulation. Labels and warning signs, for instance, are a traditional means to guide people's daily choices; the alternative - constant individualized supervision - would be much too expensive. The relative effectiveness of risk disclosures, however, bears on whether private parties have proper incentives to process information carefully and react in a socially optimal way. This includes updating personal knowledge, correcting for misperceptions, taking self-protection measures, and reporting violators. But several obstacles currently stand in the way of responding optimally to information provision.

First, it is well-known that people's risk perception is subject to several cognitive biases.⁸ For instance, the so-called "availability heuristic" entails that someone will often deem an event to be probable or frequent to the extent that its occurrences can easily be recalled or visualized. Because of this, some labeling policies may end up having little impact on people's behavior.

dispute with the United States. A recent judgment by the World Trade Organization supported the US position, but the EC has refused to backtrack. As a consequence, the WTO has allowed the US to take unilateral trade sanctions against the EC, up to a pre-established ceiling.

⁶ A 1983 report by the National Research Council estimated, for instance, that the damages on human health had been formally identified for only 7000 chemicals over a total of 5 million substances.

⁷ Let $u(\cdot)$ denote the decision maker's utility function. Then $-u'(\cdot)/u(\cdot)$ is the coefficient of absolute risk aversion and $-u''(\cdot)/u'(\cdot)$ is the coefficient of absolute prudence. The latter was introduced by Kimball (1990) and measures the strength of precautionary motives; the larger it is, the more the decision maker would be willing to sacrifice on current consumption in order to prepare against future exogenous risks.

⁸ For a survey of risk perception issues and of decision processes for low probability events, see Camerer and Kunreuther (1989). One may also look at Smith (1992) on the relationship between risk perception, information on risk, and behavior under uncertainty, and at Lopes (1992) for misconceptions concerning the public's ability to perceive risks adequately.

The various ways of framing and communicating risk also have an effect on people's perception. Hence, public trust in institutional channels that convey information about risk does influence people's perceptions. Environmental and health risks are often deemed to be greater than they really are when institutions are less trustworthy, as the recent turmoil about the spread of mad-cow disease in Europe illustrates.⁹ The formats and channels by which risk communication is made will then automatically confer or not some credibility to the information that is being transmitted.

Furthermore, many risk bearers might lack sufficient assets for reacting properly to news about risk (Shavell 1993). They may also be afraid of reprisal from the violator. Or the current hazard might constitute a "public bad," meaning that the potential harm is so dispersed and the victims so spread out through time or within the whole population that risk bearers do not find it worthwhile to report most prejudices.

These difficulties suggest that in order to be fully effective risk disclosures should be set along with complementary regulations and strategies for managing risk (Tietenberg and Wheeler 2000). Such strategies include the promotion of appropriate rules and standards for gathering, analyzing and communicating information about risk, widespread systematic training so that people recognize warnings and know what to do when they see one, the provision of accessible means – some through the judiciary system, some through the insurance industry - for self-protection and the investigation of complaints, and the introduction of credible sanctions in order to deter violations. Other strategies, however, might become obsolete as the practice of risk disclosures prevails; the mandate of some government agencies, for instance, will have to be revised, from the actual one that fits a single dominant enforcement entity to another that rather suits an enforcement facilitator.

A small but growing literature examines whether current risk disclosures are truly effective. Rechtschaffen (1999), for instance, provide a detailed analysis of the impact of California's Proposition 65. This regulation requires disclosure of exposure to a listed risk unless the firm can show that the exposure level is not harmful. It apparently had a major effect on the plumbing industry's elimination of lead in brass, faucets, submersible well pumps and water

⁹ Another account of the impact of public trust in risk management institutions can be found in Groothuis and Miller (1997).

meters.¹⁰ Other studies focus on capital market reactions to public announcements (for instance, Hamilton 1995; Konar and Cohen 1997; Badrinath and Bolster 1996; Dasgupta, Laplante, and Mamingi 1997). An interesting issue here is the timing of reactions. Laplante and Lanoie (1994), for instance, find that Canadian stock markets do not react so much to first announcements of incidents as to news concerning suit settlements and investments in pollution abatement. This contrasts with the American stock market, which seems to respond immediately to law suits announcements (see Muoghalu et al. 1990). It can be seen as an illustration of the complementarity between risk disclosure and state enforcement: Laplante and Lanoie attribute their finding to the fact that the Canadian government seems relatively more lenient on violations of environmental regulations, so Canadian investors will base their decisions on outcomes. Other empirical works, finally, examine the reactions of risk bearers to different communication strategies such as advertising campaigns (Doyle et al. 1990), labeling (Magat and Viscusi 1992), and blacklisting (Afsah, Laplante and Wheeler 1996; Foulon, Lanoie, and Laplante 1999). The main conclusion is that environmental risk disclosures do produce improvements, but that the format and scope of announcements matter.¹¹

Economists, however, would point out that effectiveness is only part of the justification for choosing to regulate through information. A more fundamental reason for supporting health and environmental risk disclosures is that they may favor ex post allocative efficiency.¹² This view is based on the Coase theorem which states that, under clearly predefined stakes (property rights, entitlements) and zero transaction costs, letting the interested parties interact and bargain with each other produces an efficient allocation of resources.¹³ Disseminating information and empowering private risk bearers might therefore be wise. First, it reduces the transaction costs attributed to asymmetric information and opportunism.¹⁴ Second, in a world where innovation

¹⁰ I am grateful to Tom Tietenberg for mentioning this study.

¹¹ In their recent survey of the empirical literature on environmental risk disclosures, Tietenberg and Wheeler (2000) conclude, for instance, that: “Disclosure of overall performance seems to encourage pollution abatement, while focusing only on some pollutants may simply result in substitution toward undisclosed forms of pollution.”

¹² This does not mean that economists view effectiveness and efficiency as two separate things. To be sure, disclosures should modify behavior (that’s the effectiveness part), but in a way that ensures an efficient allocation of resources (that’s the efficiency part).

¹³ Posner (1993) provides a nice appraisal of the impact the Coase theorem for law and economics.

¹⁴ This assertion must be qualified. It is a basic statement in game theory that spreading information in a multiple-person setting might actually worsen the outcome to everybody. This is clearly the case, for instance, in the

runs at a high pace, bringing new products or processes whose impact on health and the environment is unknown and controversial (Godard 1993), it may enhance consensus and thereby alleviate worries and disagreements over the very implications of some property rights.

Finally, public disclosure of health and environmental risks can be justified on ethical ground. As the distribution of income can violate some fairness principles, the distribution of risks can be unfair to some people. One basic question in risk bearing is whether a given risk is freely accepted, such as (in principle) the risk of injuries and death someone is exposed to when travelling in a car, or whether it is inflicted, such as the risk (before it was disclosed) of asbestos-poisoning faced by construction workers or of lead-poisoning faced by children living in older houses covered with deteriorating lead-based paint.¹⁵ Clearly, the latter should be avoided as much as possible, and making all interested parties aware *ex ante* of the potential hazards they might have to face is one necessary (albeit not sufficient) way to go.

2.2 Implementation issues

The implementation of health and environmental risk disclosures raises many questions of interest to firms and regulators. For instance, what should be the scope and content of reports? Should they refer exclusively to a predetermined list of dangerous products and processes, or should they be expected to also speak about contingency plans, risk management systems or newly discovered hazards? A related matter is the quality of the information that is provided: how can the public be ensured that the announcements are faithful and reasonably accurate? As mentioned in the previous section, communication strategy, which includes the sources that will provide information, the instruments that will gather it and the media that will convey it, constitutes an important topic as well. The timing and frequency of disclosures are also key matters. Should disclosures be annual, seasonal or monthly? Should they accompany any change of the firm's financial structure, any modification to an existing industrial plant, any submission for a patent, or any reorganization of work and amendment to the current

technology area, where proprietary knowledge is a necessary ingredient of innovation. For concrete illustrations in a regulatory context, one may see Che and Earnhart (1997).

¹⁵ Above certain levels, lead in a child's body may entail lowered IQ, learning problems, impaired hearings, and other disabilities. Tietenberg and Wheeler (2000) report that "more than 80 percent of the U.S. housing stock built before 1978 – some 64 million residences – is estimated to contain lead paint." For an economic analysis of information issues and lead-paint law, see Miceli, Pancak and Sirmans (1996).

management system? Finally, one may wonder whether disclosures should be voluntary or mandatory.

Environmental economics offers yet little guidance on those issues. Useful insights can come, however, from the fields of information economics and accounting, where disclosures constitute a more traditional subject.¹⁶ One starting point is the literature on signaling games and screening (see, for instance, Fudenberg and Tirole 1991, chapter 5). It sets up the basic structure of mechanisms such as “green labeling,” insurance contracts, and “green pricing,” which might automatically sort out the low risks from the high risks. A complementary literature is the one on “persuasion games” (see, for instance, Milgrom 1981). It deals explicitly with matters of information accuracy and quality. I shall now sketch a simple model that borrows from both literatures and brings preliminary answers to some of the above questions.¹⁷

A stakeholder (I) contemplates a project that has a probability π of being safe (g) and a probability $1-\pi$ of being dangerous (b) for human health or the environment. The stakeholder might endorse that project or not. If she does and the project turns out to be safe (dangerous), then she gets a positive payoff H (a negative payoff B). If she does not, then the project is dropped and she gets her status quo payoff, which is assumed to be 0. The project is proposed by an entrepreneur (E) who actually knows a priori whether it is safe or not. The entrepreneur’s ex post payoff is strictly positive or is equal to 0, depending on whether the project gets endorsed or not. The entrepreneur might therefore seek to convince the stakeholder by disclosing more or less accurate information concerning the nature of the project. Let the endogenous precision (or quality) of the information provided be represented by a number $\beta \in [0,1]$: β is the likelihood that a stakeholder’s evaluation of the project based on the delivered information will be positive given that the project is truly safe and negative given that the project is dangerous.¹⁸ A number β strictly between 0.5 and 1 thus captures the situation where the entrepreneur provides faithful,

¹⁶ Accounts of current best practices and part of the abundant psychological and sociological literatures on communication would also prove useful. Covering also these areas, however, goes beyond the scope of this chapter.

¹⁷ A more detailed presentation and analysis of this model can be found in Sinclair-Desgagné (2000b). Related models and complementary results can also be found in Dye (1985), Fishman and Hagerty (1990), and Bowden (1989).

¹⁸ For simplicity, it is assumed that the probability a positive evaluation results from a safe project is always equal to the probability an evaluation turns out negative when the project is dangerous. Hence, β corresponds to the likelihood of reaching the right conclusion upon further evaluation of the project, so $1-\beta$ is the probability of being mistaken, i.e. $1-\beta = \text{Prob}(\text{positive, given unsafe}) = \text{Prob}(\text{negative, given safe})$.

albeit imprecise, information. In this case it follows from Bayes's rule that studying the entrepreneur's announcement makes the stakeholder believe the project is safe or dangerous with respective revised probabilities:

$$\begin{aligned} \text{Prob(safe, given positive)} &= \pi\beta / [\pi\beta + (1-\pi)(1-\beta)] \quad \text{and} \\ \text{Prob(dangerous, given negative)} &= (1-\pi)\beta / [(1-\pi)\beta + \pi(1-\beta)]. \end{aligned}$$

At this point the model yields a first conclusion: if information is costless and cannot be misleading, then the entrepreneur provides fully accurate information ($\beta = 1$) and so reveals the true nature of the project. This is just another statement of the so-called "disclosure principle" (Milgrom and Roberts 1986; Okuno-Fujiwara, Postlewaite and Suzumura 1990). It is supported by the following argument: the stakeholder would discount any imprecise information, because the entrepreneur has no incentives to conceal data if the project is a safe one.¹⁹ The policy implication is that the quality and content of voluntary disclosures are maximal when the public can veto a given project and information provision is free.

Disclosure related costs, however, which might come from the preparation and dissemination of reports or from the proprietary nature of information, raise a different picture. Partial information in this case cannot be exclusively associated with a dangerous project (see Verrecchia 1983). One major consequence is that, if the stakeholder holds a positive expected payoff ($\pi H + (1-\pi)L > 0$) and is thus a priori favorable to the project, then the entrepreneur would not deem it useful to produce additional information. This calls for government intervention, which can take the form of mandatory disclosures or of an advertisement campaign aimed at instilling doubts in the public's mind. The presence of a reluctant stakeholder with expected payoff $\pi H + (1-\pi)L \leq 0$ who can block the project, on the other hand, puts pressure on the entrepreneur to disclose information.

Let us examine the latter situation in the (most realistic) case where the entrepreneur cannot lie, his ex post revenue $R(\cdot)$ is highest if the project turns out to be a safe one (i.e. $R(g) > R(b)$), and the stakeholder can assess the accuracy level of disclosures. Denote $P(\beta)$ and $S(\beta)$ the entrepreneur's and the stakeholder's costs of respectively producing and studying

¹⁹ In the language of game theory, this is a "forward induction" argument. It supports the equilibrium precision level $\beta = 1$ by reasoning that the stakeholder's revised probability that the project is innocuous would be 0 if the entrepreneur switched to (out-of-equilibrium) partial disclosure and set $\beta < 1$ instead.

information of precision β .²⁰ Two situations are now possible, depending on the specific configuration of revenues and costs. In the first one, the entrepreneur with a safe project produces information of precision β such that $P(\beta)$ is just superior to $R(b)$, and the entrepreneur with a dangerous project remains silent. Upon public disclosure by the entrepreneur, the stakeholder thus infers immediately that the project is safe and endorses it.²¹ In the second case, however, disclosures are the same whatever the safety of the project; their precision is just high enough to induce the stakeholder to undertake some costly evaluation before making a decision. The project is approved if and only if the evaluation concludes positively.²² Government intervention might again be justified in this case, through subsidies to the study of disclosures or enforced standards of higher quality and accuracy.

This model sheds some light on the circumstances that trigger voluntary disclosures, on the quality such disclosures may have, and on the scope for government intervention. Once sensitive information is made available to the firm's stakeholders, however, the next questions are whether and to what extent they should be allowed to intervene in the firm's management. These matters are addressed in the upcoming section.

3. Stakeholders involvement

Another important trend in the regulation of health and environmental risk is the direct involvement of stakeholders in the assessment, prevention and mitigation of such risks. In the United States, for example, extended liability under CERCLA regulation – the 1980

²⁰ The two functions are strictly convex and increasing on the interval $[0.5,1]$, with $P(0.5) = S(0.5) = 0$ and $P(1) > R(g)$.

²¹ This equilibrium is also based on forward induction arguments. The stakeholder believes that (out-of-equilibrium) additional information of precision β such that $P(\beta) < R(b)$ (resp. $P(\beta) > R(b)$) can only be supplied under a dangerous (resp. safe) project; her revised probability that the project is safe is then set to 0 (resp. 1) in this case and the project is not endorsed (resp. is endorsed).

²² Denote β^* the accuracy of disclosures at this equilibrium. It is the unique β that maximizes (we assume of course that this maximand exists) the entrepreneur's expected payoff under stakeholder evaluation, i.e. that maximizes $\beta H - P(\beta)$ under the constraints that the stakeholder prefers to further evaluate the project rather than to either veto it [formally, $\pi\beta G + (1-\pi)(1-\beta)B - S(\beta) \geq 0$] or endorse it right away [$-(1-\pi)\beta B - \pi(1-\beta)G - S(\beta) \geq 0$]. The forward induction argument that supports this equilibrium runs as follows. Disclosures of precision $\beta \neq \beta^*$ such that $P(\beta) < R(b)$ (resp. $P(\beta) > R(b)$) can only occur under a dangerous (resp. safe) project; the stakeholder's revised probability that the project is safe is then set to 0 (resp. 1) in this case and the project is not endorsed (resp. is endorsed).

Comprehensive Environmental Response, Compensation and Liability Act – provides incentives to lenders, clients and former owners to get involved in the monitoring and control of the firm’s activities. Similarly, the 1996 Risk Management Planning program of the U.S. Environmental Protection Agency and the European Seveso Directives both require that firms under their jurisdiction cooperate closely with their employees and local communities on several facets of risk management. This section surveys some of the recent contributions to the analysis and design of such regulations. The first part discusses risk sharing issues. The second part focuses on risk control and incentives for risk reduction.

3.1 *Risk sharing*

From a risk-sharing viewpoint, there are at least two reasons for having some nonpolluting stakeholders share the consequences of a firm’s environmental mismanagement. First, the firm belongs usually to an entire production chain which includes other organizations as well. Financial institutions provide funds to support the firm's activities. Business partners supply key materials, designs and advice, or place orders on the firm's products. Public agencies are asked to deter individual or group behavior that would increase the riskiness of some industrial activity. And local governments must enforce zoning laws and design effective emergency programs in order to mitigate the consequences of industrial accidents. Each one of these organizations therefore contributes to the level of risk inflicted on health and the environment and should take responsibility for it.²³

The second reason bears on the necessity to compensate victims fairly and effectively. The polluter-pays principle is a widely accepted rule to allocate the financial burden of environmental remediation. Its application, however, is exposed to several problems that delay and constrain the compensation of victims: first, it might be difficult to identify the polluter ; second, insurance contracts are often invalidated by some clauses the polluter will fail to satisfy ; and third, polluting firms are frequently subject to limited liability. One can therefore see the

²³ This is a normative as well as a positive statement. A striking illustration of it was the 1997 lawsuit that the French water supply company “Lyonnaise des Eaux” launched against the French Government (*Le Monde*, January 24th, 1997). Increasingly attacked by angry residents of Brittany who complained about the poor quality of drinking water, the company charged the government with not enforcing current French and European regulations against agricultural pollution of water.

creation of special funds financed by taxation, such as Superfund, and the introduction of new regulations extending responsibility for cleanup beyond the firm's legal borders as natural answers to those shortcomings.

One downside of an extended liability regime, however, is that such a regime might encourage firms to cluster with partners that exhibit similar safety standards, degree of solvency, and risk preferences. This may not be socially optimal, because it may bind together the more reckless firms and slow down the diffusion of best practices. So while extended liability may improve risk sharing, it may not necessarily increment social welfare and some tradeoff must be made.

Another economic drawback of extended liability is that the targeted firm might change its pattern of transactions and expose less capital to liability when it cannot invest in safety or control the risk (Boyd and Ingberman 1997). Consider, for example, the case of a firm that could be held liable for the health and environmental consequences of a leak in a landfill owned and operated by another firm where its toxic wastes are buried. That firm is likely to distort its capital investments and output choices in order to limit the amount of wealth exposed to liability.²⁴ This brings us to the matter of incentives.

3.2 Incentives for risk control

A major motivation for encouraging stakeholders to get involved in the firm's risk management is that it may improve control over the prevention and mitigation of risks. This rationale is recognized explicitly, for instance, in the following verdict concerning lender liability.²⁵

Our ruling today should encourage potential creditors to investigate thoroughly the waste treatment systems and policies of potential debtors. (...) creditors' awareness that they are potentially liable under CERCLA will encourage them to monitor the hazardous waste treatment systems and policies of their debtors and insist upon compliance with acceptable treatment standards as a prerequisite to continued and future financial support. Once a secured creditor's involvement with a facility becomes sufficiently broad that it can anticipate losing its exemption from CERCLA liability, it will have a strong incentive to address hazardous waste problems at the facility rather than studiously avoiding the investigation and amelioration of the hazard (...).

²⁴ For instance, the firm could be lead to either acquiring the landfill or selling out the activity that produces toxic waste. For empirical evidence on the latter, see Ringleb and Wiggins (1990). According to this study, changes in U.S. liability laws through the period 1967-1980 lead a significant proportion of larger corporations to withdraw from hazardous sectors.

²⁵ More details and discussions about this verdict can be found in the *Journal of Environmental Law*, 1, 145-151.

Such a ruling was also meant to deter certain practices of investment, divesture and outsourcing. To outsource activities that take place under heavy competition, like transportation, is appealing since it lowers the cost of those activities. But transferring risky activities to competitive subcontractors might result in lower effort devoted to safety. Small subcontractors often cannot manage these types of risks nor insure themselves properly. Furthermore, their limited liability can make them more reckless, taking less precautions and underinvesting to protect their assets, since they may use the shelter of bankruptcy laws in the event of an accident. One solution to this was to confer credibility to the threat of tracing all firms linked to the risky activities by the fact that they either possess critical information about safety, or that they own, produce or procure the processes or the products at stake.

Stakeholders involvement for the purpose of risk control, however, raises a number of specific issues that will now be explored.

- *The extent of involvement*

A firm's stakeholders include the shareholders and the lenders, the insurers, the employees, the customers and suppliers, certain regulatory agencies, and the local communities. Clearly, not all of them can or should get involved in the firm's risk management to the same extent nor on the same dimensions.

Let us first consider the insurers. Demand for insurance by industrial firms results usually from their shareholders' and lenders' risk aversion. It is also linked to liability laws in an important way: firms do not have much incentive to insure if liability for damages falls on someone else. In some contexts, insurance might be mandatory, in order to enhance the compensation of victims who would otherwise face a bankrupt firm. The key role insurers can play in risk reduction is now well documented.²⁶ Their intervention, however, is mostly confined to arm's-length contracts.²⁷ By design, the elements of such contracts – the premium, the extent

²⁶ For a concrete illustration, see for instance the reports by Paté-Cornell (1994) and Er, Kunreuther and Rosenthal (1998) on the specific case of industrial boilers.

²⁷ That is, binding agreements of limited scope that circumscribe the amount and type of information to be used ex post by each party.

of coverage, the restrictions, exclusions and deductibles – aim at separating and dealing with the various sizes and types of risks.²⁸ The insurer can thereby play the role of a surrogate regulator.²⁹

The extent of bank liability was recently studied by Boyer and Laffont (1997).³⁰ They consider a formal model involving a regulator, a bank and a firm. The relationship lasts two periods. In each period the firm is presented an investment opportunity that yields uncertain returns and might also damage the environment. The firm can affect the probability of harm through some efforts which cannot be observed by either the bank or the regulator, but it has limited liability. It is tied to the bank by a two-period loan contract, however. In this context, arm's-length involvement by the bank also seems to be sufficient. By making the bank partially liable for environmental damages, the regulator can bring about a contract that makes the firm trade off financial returns and environmental risks in a (second-best) socially optimal way.³¹

Government intervention with respect to major health and environmental risks has traditionally been more extensive and direct.³² Market-based instruments such as Pigouvian taxes and tradable permits, while they generally enhance cost-effectiveness and efficiency, do not deal very well with actions that are discrete and difficult to monitor, as it is often the case for those actions that lead to major industrial accidents. Legal liability rules also have limitations imposed by uncertain causality and by bankruptcy laws. They are thus invariably complemented with safety regulation. Defining safety standards and obligations, together with fines and other sanctions for noncompliance, remains in fact the most common approach to regulating hazardous processes and products. Table 1 shows a list of existing command-and-control regulations designed to reduce risks. Banning some products or processes is another, albeit radical, avenue that is often taken. The fact that society may be losing some benefits in this case can be justified

²⁸ There is a huge literature on insurance. For a presentation of the insurability problems associated with new environmental and technological risks and how they can be addressed, see Dionne (1992).

²⁹ Of course, there can be good and bad surrogates. The government must then intervene upstream on the regulation of reinsurance and the definition and design of emergency measures. See Kunreuther and Roth (1998).

³⁰ Other contributions to the topic of lender liability include Heyes (1996), Segerson (1993), and Lewis and Sappington (1999), Boyer and Sinclair-Desgagné (2000). For a good survey on the topic of liability, see Segerson (2000).

³¹ In some case, the regulator might have to also subsidize the bank for lending the money. Note also that in other circumstances an opposite conclusion may hold (see Pichford 1995).

³² For a good overview of the role government can play in the management of environmental risks and an analysis of the efficiency of different policy instruments, see Segerson (1992).

by the precautionary principle, or because it would not be the firm's best interest to incur the cost of finding out the true risks involved (see Shavell 1993). Public intervention can also take the form of a subsidy for the development of safer products and processes. In this case, the government seeks to both control behavior and enhance innovation, two goals that can be more easily achieved by a scheme that sets certain standards on the one hand and supports effort to innovate on the other (Carraro and Siniscalco 1996). Finally, many official reports and inquiry suggest that government intervention be based on "goal setting" instead of standard-setting regulation.³³ Under the former, a firm must convince the regulator that its processes, products and operations are safe rather than comply with pre-specified technologies and checklists. Supporters of this proposal argue that it may leave more room to the firm. But it may also entail that the government would know better and perhaps get more involved in the firm's organization and management.

After considering each stakeholder separately, one may ask what is their joint effectiveness and impact on the firm. The general conclusion is now that the costs to the firm of bringing in various stakeholders with different objectives would be an erosion of strategic focus (Dewatripont, Jewitt, and Tirole 1999) and a general reduction of managerial incentives.³⁴ Dixit (1996) provides an interesting explanation for the latter: a given stakeholder may find it worthwhile, because this decreases her own cost of incentive provision, to insure the firm's managers against under-performing in some dimensions that she values little; as this practice spreads, however, the stakeholders end up neutralizing each others' incentives.³⁵ An important benefit of involving several stakeholders, on the other hand, is that it might alleviate some intrinsic biases that would otherwise have plagued the firm's decision making (Tirole 1999).

³³ The Three Mile Island and the Piper Alpha reports both insisted on this aspect. See Paté-Cornell (1994) and Lees (1996).

³⁴ The scheme from Sinclair-Desgagné (2000a) that is sketched in the upcoming section would mitigate the latter effect.

³⁵ In the Holmström and Milgrom (1991) framework, Dixit (1996) was able to show, furthermore, that the strength of incentives decreases proportionally to the number of stakeholders.

Table 1 Command-and-control regulations to reduce risk
Occupational safety and health regulation
Public health regulation (food and drugs, etc)
Broad environmental regulation: air, water, ground quality, impact assessment, etc.
Flammable, explosive and fire regulation
Toxic substances regulation
Labelling regulation
Storage regulation
Waste disposal regulation
Transportation regulation
Consumer product safety regulation
Ports and waterway safety regulation
Nuclear installations regulation
Other energy specific regulation

- *The locus of involvement*

An issue that is unseparable from the extent of stakeholders involvement, especially when this involvement is not supposed to be an arm’s-length one, is the precise domain of stakeholders intervention. This matter is akin to organizational and job design, and economics has yet little to say about it.³⁶ Clearly, one would not expect to see local communities and government agencies get involved in most aspects of the firm’s strategic planning activities, for instance. There is one area, however, where close contacts between the firm and some of its stakeholders are widely seen as necessary: emergency planning.

Several studies have shown that, in case of a major industrial accident, losses of lives and human injuries could be significantly reduced under effective emergency measures.³⁷ Hence,

³⁶ A notable exception on the subject of job design is Holmström and Milgrom (1991).

³⁷ See, for instance, the 1975 report by the Atomic Energy Commission. There are typically three sorts of industrial accidents: explosions, fires, and leaks. Each one raises specific emergency planning issues (see Lees 1996).

recent regulations and even some insurance contracts now require that firms dealing with hazardous processes and products develop emergency response programs. The main components of an emergency plan include the assignment of tasks and responsibilities, communication scenarios, specification and implementation of clear rules, procedures and routines, and coordination amongst various external and internal risk bearers. Close collaboration and training of employees, public security teams, and neighbors is seen as determinant for the eventual scale of damages. Moreover, it is not sufficient that emergency plans be thoroughly designed. One of the main lessons from the past is that these plans should be kept as simple and flexible as possible, so that they can be scaled up or down according to circumstances (see Lees 1996, volume 2). They must also be put to trial and reassessed regularly. This requires time and resources since the firm's operations will often be interrupted. This also requires that the firm be somewhat transparent vis-à-vis its workers and the surrounding communities. Unless a culture of safety is well embedded in the firm *and* shared amongst public security officials and local residents, eventual damages are bound to be large.

Stakeholders might also ask for a global picture of the firm's risk assessments and management systems. Such a proposal is actually being implemented in many organizations. It will now be discussed.

4. Integrated risk management

Firms dealing with significant health and environmental risks are increasingly seeking to implement an *integrated* approach to risk management. Demand for such an approach comes first of all from the landscape of the new economy. As globalization and deregulation have significantly lowered entry barriers and as consumers are now better informed and more versatile, most firms find themselves under pressure to manage altogether many types of risks in a systematic and cost-effective way. To be sure, the 1992 Cadbury Report asserted, for instance, that the explicit analysis by the board of directors of the firm's risk profile is an essential component of best practice for corporate governance. Integrated risk management is also an explicit item of several new regulations. The Bhopal disaster made it largely obvious that firms, especially when they experience financial turmoil, often tend to focus on short-term production and the specific risks it entails, thereby neglecting long-term risks to human health and the

environment (Lees 1996).³⁸ Other studies have revealed, furthermore, that major deficiencies often exist in communication and coordination between the divisions of the firm that deal with insurance matters and portfolio investments and the production staff who take care of safety (Paté-Cornell 1996). In a 1988 report to the U.S. Congress about facilities emergency systems to monitor, detect, and prevent chemical accidents, the EPA concluded already that “the prevention of chemical releases requires an integrated approach that considers technologies, operations, and management.”

This section therefore presents some of the main issues and research relevant for an integrated approach to risk management. Part one explains the nature and scope of integrated risk management. Part two discusses its implementation.

4.1 Definition

A typical business firm faces many types of risks. In addition to health and environmental risks, there are the other regulatory risks – antitrust, for example - and the competitive risks inherent to the industrial sector. Some risks are also generated by the broader political, economic and social systems in which the firm operates. The past decade saw a mounting sense amongst corporate boards of directors and public policy makers that letting each functional division of the firm manage its corresponding risks separately from the other divisions might not be an appropriate way to go. What was increasingly needed was a comprehensive approach to risk that would provide a complete picture of the firm’s risk profile. Several firms therefore ventured to create such an approach, which is now known as integrated (or holistic, strategic) risk management. For instance, Nottingham (1997) reports that Microsoft “(...) started with a series of “risk maps” that plotted Microsoft’s natural, operational, legal, financial and human resources risks on graphs. Risk severity was placed on the vertical axis and frequency on the horizontal axis, and a single aggregate risk potential was plotted for each organizational risk. (...) Collectively, the maps provided top executives with an inventory of their organization’s risks.”

Although many firms have followed Microsoft’s example, there is not yet a precise definition of integrated risk management. Managers generally agree, however, on what it should do (see The Economist Intelligence Unit and Arthur Andersen 1992; Nottingham 1997). First, it

³⁸ Of course, other factors contributed as well to the Bhopal disaster, including lack of personnel training and bad communication.

should clarify the risk *context* for the firm's top managers. Second, it should highlight the *interdependencies* between risks. Third, it should provide a framework for *communication* and comparison of specific risks throughout the organization. Fourth, it should indicate the *organizational means* and the resources necessary to deal properly with the various risks. And fifth, it should be a proactive process and a key part of the firm's *strategic planning*.

The implementation of integrated risk management raises a number of issues that I will now address briefly.

4.2 Implementation

Integrated risk management is a wide-ranging goal that will undoubtedly mobilize most of the firm's instruments of corporate governance.³⁹ I shall focus here on three dimensions of implementation that are often deemed to be essential: leadership, communication, and reviews.

▪ Leadership

Poor involvement of high executives in risk management is often mentioned as a factor contributing to higher levels of risk. It was one of the lessons learned from the Seveso accident, where the directors of the corporation that was ultimately found responsible were unfamiliar with the hazards. It was also one of the main remarks of a report that led to the shut down of seven nuclear reactors in Canada in 1997.

Integrated risk management, in particular, requires credible and active involvement of the firm's top officials for several reasons. First, since it is a top-down request, it is likely to be forgotten or to be significantly altered if the firm's executives are not committed to it and do not actively follow up on its development. Second, its implementation and the recommendations it will periodically yield might bear important budgetary consequences. But without explicit involvement at the topmost level, funding allocations are likely to deviate from the suggested ones. For business culture often disregards the contribution of some prevention measures and organizational controls to reduced liability, lower insurance premiums, better access to capital and stronger partnerships, particularly when prevention is targeted at low probability events. This

³⁹ For a review of those instruments and their potential role in environmental risk management, see Gabel and Sinclair-Desgagné (1995).

is actually why minimal expenses towards safety are often set by regulation, industrial standards or insurance companies.

Implicit in the discussions concerning the involvement of top executives is the issue of leadership. Economics has little to say about how a firm's executives can display leadership when they need to. A notable exception is a recent paper by Hermalin (1998). This article sees leadership as the ability to be followed voluntarily. As it turns out, one way to achieve leadership in this sense is to convey the message that valuable resources are currently being expended pursuing the proposed goal. In the present context, this suggests that corporate boards seeking to implement integrated risk management might foster corporate risk audits and perhaps create a specific executive position – that of “Chief Risk Officer.” The latter proposal is now being considered in many organizations.

- *Information systems*

Successful integrated risk management relies on collecting and disseminating timely information about both the external business landscape and the performance of internal management and operations. The risk management web site created at Microsoft illustrates one aspect of such an information system (see Nottingham 1997). This web site provides executives with summaries concerning 60 key risks being tracked by the organization; summaries are of course supported by detailed analyses that are also made available. Also worth mentioning is the case of Syncrude Canada, an oil producer:

The organization has an active risk management network, composed of individuals from across the organization, to communicate information about risk management from all areas of the organization to a central point and, in turn, disseminate information back to all departments. (Nottingham 1997, p. 17)

Any information system, however, must resolve a basic tradeoff between specialization and communication. On the one hand, specialization and focus are the only answers to information overload and might furthermore increase productivity, on the other hand, information sharing and communication are more difficult when people hold specific data and viewpoints (and languages!). The formal analysis of this tradeoff dates back at least to Marschak and Radner (1972)'s *Economic Theory of Teams*. More recent contributions include the article by Bolton and Dewatripont (1994) who provide insights as to how information can be aggregated up. Another

well-known tradeoff is the one between type I and type II errors. The former is defined as the likelihood of rejecting valuable business opportunities and it is increased by centralization. The latter refers to the probability of undertaking harmful initiatives and it tends to go up under *decentralization* (meaning less supervision and greater empowerment). Analyses of this tradeoff can be found in Beckenstein and Gabel (1986) and in Sah and Stiglitz (1986). Conclusions vary according to specific features of the organization and of its business environment.

Another key issue in the design of information systems is how current data are being generated. To evaluate their current management systems, for instance, business organizations increasingly make use of internal audits. Good audits depend on the rules for selecting and training auditors, and on the scope and methodology of auditing. These features, however, constitute a public good; hence, they might remain obscure and of poor quality without public intervention. Significant advances were made recently by the publication of the European EMAS and of the ISO 14010-12 standards for environmental auditing. In Sinclair-Desgagné and Gabel (1997) we submit, furthermore, that internal audits should not only be designed and used to extract information, but also to provide managerial incentives.

- *Reviews and internal incentives*

One fundamental criticism of integrated risk management is that its implementation might lead to a drop in the power of incentives.⁴⁰ Integrated risk management entails that the impact of an employee's actions to manage his local risks on the risk level of the firm's other departments is now considered. This amounts to, first, making the manager accountable to more principals (the risk managers of the other departments), and second, to adding new tasks to the manager's current job (e.g., gathering and processing information about the risks of the other departments and the global risk profile of the firm). The discussion of the previous section has mentioned already that one consequence of introducing more principals would be to soften incentives (Dixit 1996; Tirole 1999). Moreover, making the manager's job more complex by adding new tasks entails that incentives might have to decrease further in order to motivate the manager to keep in mind and act according to the larger picture (Holmstrom and Milgrom 1991).

⁴⁰ Williamson (1985) uses the term "high-powered incentives" to denote compensation schemes that are very sensitive to outcome. Such schemes seem to prevail in the market whilst large organizations and public bureaucracies rather exhibit "low-powered incentives," i.e. compensation that varies little according to short-term results.

In Sinclair-Desgagné (2000a) I propose a simple mechanism that might overcome this scenario.⁴¹ This scheme alleviates at the same time the logic of multiple tasks and the effect of competition amongst principals. It also emphasizes the role selective audits and reviews could play in the provision of incentives. In the present context, it can be described as follows. Let a given manager of the firm have now two principals - the previous one and the director of another department whose risk profile interacts with that of the manager's own department. Unfortunately, effort spent by the manager to deal with his department's risks increases the marginal cost of putting more attention into not increasing the risks of the other department. Let the manager's own department monitor him and set his compensation based *only* on local results. Under integrated risk management the other department's director will observe those results; let her commit to audit the manager only when they are *greater* than some threshold (the rationale being of course that good local results might be achieved at the expense of internalizing the other department's objectives). The other department does not interfere with the manager's compensation unless current local results trigger an audit. In this case, if the manager's impact on the reduction of global risks appears to be poor, then his compensation is lower than it would have been if no audit had occurred. On the other hand, if the audit finds out that the manager did very well with respect to integrated risk management goals, then he gets a significant bonus. This carrot-and-stick package would be designed so that, *ex ante*, the manager would *want* to be audited. Under this scheme, the direct conflict between the two principals and the strict tradeoff affecting the manager's effort allocation, two related features which underlie low-powered incentives, might be avoided. Indeed, the manager is now doubly motivated to achieve good local results, first by his own department's incentive scheme (which does not need to be any different than if there was no global considerations) and also by the fact that audits are attractive. But the manager finds it even better to seek outstanding local results when reasonable efforts were devoted as well to integrated risk management. In other words, incentives are such that effort expended on local risk management and that put towards integrated risk management have become complementary.

⁴¹ This scheme is an extension to common agency of the one-principal version presented in Sinclair-Desgagné (1999b) and Sinclair-Desgagné and Gabel (1997).

5. Concluding remarks

This chapter has surveyed three main topics of increasing concern to business firms dealing with health and environmental risks: public disclosures of health and environmental hazards, stakeholders involvement in the firm's operations, and integrated risk management. Particular attention was given to the underlying rationales of these approaches and to implementation issues.

Another relevant topic I might have considered is the impact of new regulations concerning product sponsoring and the traceability of hazardous substances. Such regulations have long been suggested in ecological economics. New developments in information technology and data analysis are now making them increasingly attractive, and they are indeed developing rapidly, particularly in Europe. An example would be the recent rules approved by the European Parliament (though not enforced yet by member countries) forcing carmakers to bear the cost of discarding their products (*International Herald Tribune*, February 4th, 2000). Computer hardware manufacturers might face a similar pressure soon. A satisfactory treatment of this subject, however, needs to be postponed to another paper.

I shall end this chapter with a list of generic tradeoffs of concern to both public-policy makers and corporate management dealing with health and environmental risks (Warner et al. 1992), particularly when considering the three topics of this chapter - public disclosures, stakeholders involvement, and integrated risk management. As I will point out, some partial answers have already been provided and were summarized in the previous sections. But much work remains to be done, and the items on the list would still constitute a valuable research agenda.

(1) *Prevention or contingency planning ?*

Standard economic reasoning would conclude that the respective expenses on prevention and on contingency planning should be set such that the entailed net marginal benefits are equal. The problem in practice is there might be indivisibility constraints and also uncertainty concerning the relative effectiveness of each approach. Stakeholders might therefore bear different opinions and disagree on the proper allocation of resources, according to their respective risk attitudes and probability assessments. This will have an impact on the content and format of disclosures, as

well as on the outcome of stakeholders involvement and on the design of integrated risk management systems. As argued in 3.2, furthermore, the public is likely to intervene more frequently and deeply within the firm when emergency measures are being planned. Would this create a bias in favor of preventive care? More generally, what is a socially optimal allocation and what contextual factors (i.e. upstream and downstream competition, regulation, organization, and technology) does it depend on?

(2) *Punish or forgive ?*

Dynamic efficiency and learning about risk control require that information concerning near-misses, alerts and other deficiencies be disclosed and discussed. However, the implementation of any system aimed at revealing such information is likely to face resistance. The fear of reprisal naturally leads employees to hide problems, mistakes and errors. But risk control and safety cannot improve as much without their openness. Hence, in order to encourage information revelation several experts favor a forgiving approach rather than a carrot-and-stick one with respect to individual performance in risk management. Where the line is drawn obviously matters for the mandatory nature and content of public disclosures, as well as for the design of *internal* disclosures that constitute a key ingredient of integrated risk management. A related set of issues concerns the type of punishment to be inflicted, and on whom within the organization. Those issues have been addressed formally by Segerson and Tietenberg (1992) and Sinclair-Desgagné (1994). A challenging topic from both corporate management and public policy angles is the complementarity between firm and regulatory incentives for environmental risk management.

(3) *Quantitative or qualitative assessments ?*

This issue is a crucial one in risk communication. In practice, current methodologies of risk assessments, together with insurance contracts and regulatory requirements, favor a numerical approach. Some experts argue, however, that too much focus on quantity might lead to neglecting some rare events and certain outcomes that are more difficult to describe. This matter has ramifications in cognitive psychology, and it bears consequences for the economics of disclosures. I have presented in subsection 2.2 a model of disclosures that brings together several

features of signalling games and of persuasion games. The present discussion suggests, furthermore, to seek contributions from the fields of behavioral and experimental economics.

(4) *Technology or organization ?*

This chapter emphasized organizational means of risk control (incentive compensation, audits and information systems).⁴² Firms, however, often have a tendency to prefer technological solutions. An important issue in risk management, particularly in a context where different stakeholders are involved, is whether and to what extent technology and organization are substitutes or complements. This issue is raised by Paté-Cornell (1996), who suggests that its further study is a necessary component of integrated risk management.

(5) *Is risk management profitable to business or not ?*

The question is related to the Porter hypothesis that has been, and is still, the subject of many debates within regulatory and managerial circles.⁴³ All members of the firm face this tradeoff, from the bottom hierarchical levels to intermediate managers up to the board of directors: high-ranked executives must decide on the financial resources that will be devoted respectively, say, to safety and to market research, whereas the foreman must decide whether or not he should spend an extra day double-checking safety procedures instead of spending time on more productive (and often more visible) activities. The incentive scheme in Sinclair-Desgagné (1999b) suggests that one might be able to create synergies between regular business tasks and risk management. How and when such a scheme could be implemented in concrete settings, however, awaits further clarification.

⁴² Other organizational instruments that were overlooked in the above sections include recruitment, training and career development, and corporate culture. For a discussion of these, see Gabel and Sinclair-Desgagné (1995).

⁴³ The so-called Porter Hypothesis states that environmental regulation can (and should) also be seen as an industrial policy instrument aimed at increasing the competitiveness of firms. The underlying justification for this statement is that well-designed environmental regulation could force firms to seek innovations that would turn out to be both privately and socially profitable. Such an assertion is of course quite appealing to policy makers, for it suggests that environmental regulation could be win-win, i.e. that *all* parties could possibly benefit from it, *including* those responsible for creating negative externalities. For some discussion concerning the validity of this hypothesis, see Gabel and Sinclair-Desgagné (1998, 2000) and Sinclair-Desgagné (1999a).

(6) *Experts or lay persons ?*

When stakeholders are heterogeneous in their respective background and competence, questions concerning the extent and locus of their involvement arise naturally. As discussed above, whilst some people favor maximal openness and participation for ethical reasons, others argue that it might be necessary to restrain the pool of stakeholders in order not to dilute responsibility, incentives, and scientific information. Section 3 proposed some recent approaches to deal with this issue (see also Tirole 1999). Discussions are still going on, however, since the OECD recently recommended broader stakeholders participation in managing the health and environmental risks of the chemical industry.

(7) *Controlling end products or internal processes ?*

One last important policy issue, finally, is whether disclosures should focus on outputs and products, or rather on inputs and processes. The former prevails in international trade and is currently the source of heated disputes between the United States and Europe. The latter fits the spirit of the Risk Management Program adopted in 1996 by the US EPA. Further analyses might make a distinction between firms and industries that are vertically integrated or not. In particular, empirical and theoretical studies of risk management within the multinational enterprise would be welcome.

APPENDIX

This appendix briefly describes five relevant schemes and programs for health and environmental risk management: the Toxic Release Inventory Program, the Risk Management Program, the Seveso II directive, the ISO 14000 standards, and the environmental disclosure rulings of the Securities and Exchange Commission. An exhaustive description of these intricate rulings is of course impossible here, but additional information can easily be obtained through the large literature on the subject.

- *The Toxic Release Inventory Program*⁴⁴

The Toxic Release Inventory Program (TRI) was enacted by the Congress of the United States in 1986, as a part of the Environmental Protection and Community Right-to-Know Act. Its objective is to enhance public information and awareness about toxic substances that are released in the environment. The program sets a list of dangerous chemicals and requires that firms using, importing, processing or manufacturing those chemicals beyond a certain amount file a report each year. Reports include the names of the company and of its parent one if it exists, the type and frequency of releases, as well as a scientific rating of risk. This information is made available to the public. Separate reports must also be sent to the state and local authorities, as well as to fire and emergency officials.

Environmental Protection Agency (EPA) data reveal that total releases have gone down by 44% in the twelve years following the program's inception. According to Tietenberg and Wheeler (1998), however: "This does not necessarily imply that toxic risk has also declined by 44%. TRI discloses emissions, but does not provide complementary evidence on risk. Since risk factors for different toxics can differ by orders of magnitude, this is an important limitation of the program."

- *The Risk Management Program*

Besides the identification and disclosure of hazards, increased emphasis has also recently been put on risk management systems. For instance, the EPA adopted its Risk Management Planning

⁴⁴ This paragraph borrows without restraint from the account on the TRI program by Tietenberg and Wheeler (1998).

(RMP) program in 1996, which pursues the Clean Air Act amendments of 1990 and incorporates many recommendations of the Occupational Safety and Health Administration (OSHA) for the prevention of major risks. This program seeks, first, to improve public access to information concerning technological risks *and* their management, second, to make the EPA's current risk prevention program mandatory, and third, to articulate and implement better coordination between public and private emergency plans. The elements of RMP include:

- the review and documentation of a plant's hazardous chemicals, processes and equipment;
- detailed process analysis to identify hazards, assess the likelihood of accidental releases and evaluate their consequences;
- the development of standard operating procedures;
- specific training of employees on those procedures;
- the implementation of a preventive maintenance program;
- the documentation of how operations changes that may have an impact on safety are managed;
- reviews before the initial start-up of a hazardous process and also before any start-up following the modification of a hazardous process;
- the investigation and documentation of previous accidents;
- periodic safety audits to ensure that the recommended procedures and practices are being followed.

Firms had until June 1999 to comply with this program. It is estimated that approximately 66,000 sources are targeted by RMP. The facilities include chemical and petrochemical plants, pulp and paper manufacturers, manufacturers and handlers of chlor-alkalis, plastics, resins, and chemical fertilizers, storage facilities that use ammonia as a refrigerant, and public water treatment systems. The ruling specifies three levels of compliance. Level 1 applies to sources and processes for which a worst-case analysis of releases deems it would not affect the public. This includes, for instance, remotely located sources and processes that use listed flammable substances. Level 2 deals with activities that do not involve chemical processes, such as retailing and other processes not listed under OSHA's Process Safety Management (PSM) standards. Level 3, finally, applies to higher-risk complex chemical processes and facilities, such as those already subject to OSHA's PSM. Firms under level-one requirements do not have to implement

a prevention program, an emergency response program, nor a risk management system. Firms facing level-two or level-three requirements, however, do.

- *The Seveso II directive*

Following the 1976 accidental release of toxic dioxine in the Italian County of Seveso, members of the European Union (then the EEC) launched in 1982 a comprehensive program aimed at controlling the industrial risks associated with the production, manipulation and transportation of hazardous substances. The program has been known as the Seveso directive. It was updated in 1996 and it is now called the Seveso II directive.

The Seveso II directive is similar to the RMP program. Its objectives are to prevent and mitigate the consequences of major industrial accidents. It emphasizes right-to-know requirements, and it stresses and provides guidelines for the implementation of safety management systems and emergency plans. The directive also addresses urban planning, however, a topic that its American counterpart does not cover.

- *The ISO 14000 standards*⁴⁵

The ISO 14000 is a set of standards targeting several facets of a firm's system for managing environmental resources. The main sections of ISO 14000 are the following:

- ISO 14001 - *Environmental Management Systems* – Specification with guidance for use.
- ISO 14004 - *Environmental Management Systems* – General guidelines on principles, systems and supporting techniques.
- ISO 14010-12 - Principles, qualification criteria and procedures *for internal and external auditing*.
- ISO 14014 - Internal review guidelines to determine a corporation's baseline operating position. (This is a usual prerequisite for establishing an EMS.)
- ISO 14020-22 - Principles for *labeling* and disclosures.
- ISO 14031 - Guidance for *measuring environmental performance* over time.
- ISO 14050 - Methodology for a product's *life cycle analysis*.

Contrary to the previous programs, complying with ISO 14000 is voluntary. Moreover, these standards are not performance standards but management system ones. They simply

⁴⁵ This paragraph borrows from Kleindorfer (1997).

indicate how a firm could meet its own environmental policies through appropriate responsibility structures, communication channels, training programs, management controls and audits.

The number of firms asking for certification under the ISO 14000 is growing rapidly, especially in the U.S., where compliance with RMP often depends on ISO 14000 certification. In Europe, the ISO 14000 competes with the European Union's *Eco-Management and Audit Scheme* (EMAS). This scheme is also a voluntary program that shares the same objectives as the ISO 14000. It makes more stringent requirements, however, for instance that certification as well as information concerning continuous performance improvement be made public.

- *The SEC disclosure rulings*⁴⁶

The Securities and Exchange Commission (SEC) generally requires companies to disclose facts that are “material,” that is, significant enough to alter the perception of the public trying to make informed investment decisions. These facts include capital expenditures required for environmental compliance and pending environmental litigation that may affect the financial position of the company. The SEC does not specifically ask corporations to disclose their general environmental policies. If a company chooses to do so, however, information must be accurate and not misleading. According to Kass and McCarroll (1997): “both the increased commitment of many corporations to voluntary environmental audits and the advent of the ISO 14000 series of environmental management standards make it likely that more companies will choose, for reasons of public acceptance, to include information about their environmental policies in SEC filings.”

⁴⁶ This paragraph borrows from Kass and McCarroll (1997).

References

- Afsah, S., B. Laplante and D. Wheeler (1996), "Program-based pollution control management: The Indonesia Prokasih Program," Washington, D.C.: The World Bank, Policy Research Department, WP no. 1602.
- Atomic Energy Commission (1975), *Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Reactors*, Washington, D.C.: Report WASH-1400.
- Badrinath, S. G. and P. J. Bolster (1996), "The role of market forces in EPA enforcement activity," *Journal of Regulatory Economics*, 10, 165-181.
- Beckenstein, A. and L. Gabel (1986), "The economics of antitrust compliance," *Southern Economic Journal*, 52, 673-692.
- Bolton, P. and M. Dewatripont (1994), "The firm as a communication network," *Quarterly Journal of Economics*, 109, 809-839.
- Bowden, R. (1989), *Statistical games and human affairs*, Cambridge, U. K.: Cambridge University Press
- Boyd, J. and D. E. Ingberman (1997), "The search for deep pockets: Is "extended liability" expensive liability?," *Journal of Law, Economics & Organizations*, 13, 232-258.
- Boyer, M. and J.-J. Laffont (1997), "Environmental risks and bank liability," *European Economic Review*, 41, 1427-1459.
- Boyer, M. and B. Sinclair-Desgagné (2000), "Corporate governance in the presence of major technological risks," to appear in H. Folmer, H. L. Gabel, S. Gerking and A. Rose (eds.), *Frontiers of Environmental Economics*, Cheltenham, U. K.: Edward Elgar.
- Cadbury Report (1992), *Report of the Committee on Financial Aspects of Corporate Governance*, London.
- Camerer, F. C. and H. Kunreuther (1989), "Decision processes for low probability events: Policy implications," *Journal of Policy Analysis and Management*, 8, 565-592.
- Carraro, C. and D. Siniscalco (1996), "Voluntary agreements in environmental policy: A theoretical approach," in A. Xepapadeas (ed.), *Economic Policy for the Environment and Natural Resources: Techniques for the Management and Control of Pollution*. Cheltenham, U.K.: Edward Elgar, 80-94.
- Che, Y.-K. and D. Earnhart (1997), "Optimal use of litigation: Should regulatory information be withheld to deter frivolous suits?," *Rand Journal of Economics*, 28, 120-134.
- Cropper, M. L. (1976), "Regulating activities with catastrophic environmental effects," *Journal of Environmental Economics and Management*, 3, 1-15.
- Dasgupta, S., B. Laplante and N. Mamingi (1997), "Pollution and capital markets in developing countries," Washington, D.C.: The World Bank.
- Dewatripont, M., I. Jewitt and J. Tirole (1999), "The economics of career concerns, part II: Application to missions and accountability of government agencies," *Review of Economic Studies*, 66, 183-198.
- Dionne, G., ed. (1992), *Contributions to Insurance Economics*, Boston: Kluwer Academic Press.

- Dixit, A. K. (1996), *The Making of Economic Policy: A Transaction-Cost Politics Perspective*, Cambridge, MA: MIT Press.
- Doyle, J. K., et al. (1990), "An evaluation of strategies for promoting effective radon mitigation," Washington, D.C.: U. S. Environmental Protection Agency.
- Dye, R. (1985), "Disclosure of non-proprietary information," *Journal of Accounting Research*, 23, 123-145.
- Er, J., H. C. Kunreuther and I. Rosenthal (1998), "Utilizing third-party inspections for preventing major chemical accidents," *Risk Analysis*, 18, 145-153.
- Fishman, M. J. and K. M. Hagerty (1990), "The optimal amount of discretion to allow in disclosure," *Quarterly Journal of Economics*, 105, 427-444.
- Foulon, J., P. Lanoie and B. Laplante (1999), "Incentives for pollution control: Regulation (and?) information," Montréal: CIRANO WP no. 99s-11.
- Fudenberg, D. and J. Tirole (1991), *Game Theory*, Cambridge, MA: MIT Press.
- Gabel, H.L. and B. Sinclair-Desgagné (2000), "The firm, its procedures, and win-win environmental regulations," in H. Folmer, H.L. Gabel, S. Gerking, and A. Rose (eds.), *Frontiers of Environmental Economics*, Brookfield, VE: Edward Elgar Publishing.
- Gabel, H. L. and B. Sinclair-Desgagné (1998), "The firm, its routines, and the environment," in Tom Tietenberg and Henk Folmer (eds.), *The International Yearbook of Environmental and Resource Economics: A Survey of Current Issues*, Kluwer.
- Gabel, H. L. and B. Sinclair-Desgagné (1995), "Corporate responses to environmental concerns," in H. Folmer, H. L. Gabel and H. Opshoor (eds.), *Principles of Environmental and Resource Economics*, Brookfield, VE: Edward Elgar Publishing (first edition).
- Godard, O. (1993), "Stratégies industrielles et conventions d'environnement: de l'univers stabilisé aux univers controversés," *INSEE- Méthode*, 39-40, Environnement-Économie, 145-174.
- Gollier, C., B. Jullien, and N. Treich (2000), "Scientific progress and irreversibility: An economic interpretation of the 'Precautionary principle'," *Journal of Public Economics*, 75, 229-253.
- Groothuis, P. A. and G. Miller (1997), "The role of social distrust in risk-benefit analysis: A study of the siting of hazardous waste disposal facility," *Journal of Risk and Uncertainty*, 15, 241-257.
- Hamilton, J. T. (1995), "Pollution as news: media and stock market reactions to the toxics release data," *Journal of Environmental Economics and Management*, 28, 98-113.
- Hermalin, B. E. (1998), "Toward an economic theory of leadership: Leading by example," *American Economic Review*, 88, 1188-1206.
- Heyes, A. (1996), "Lender penalty for environmental damage and the equilibrium cost of capital," *Economica*, 63, 311-323.
- Holmström, B. and P. Milgrom (1991), "Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design," *Journal of Law, Economic & Organization*, 7, 24-52.

- Kass, S. L. and J. M. McCarroll (1997), "Environmental disclosure in Securities and Exchange Commission filing," *Environment*, 39, 4-5.
- Kimball, M. S. (1990), "Precautionary saving in the small and in the large," *Econometrica*, 58, 53-73.
- Kleindorfer, P. R. and E. W. Orts (1998), "Informational regulation of environmental risks," *Risk Analysis*, 18, 155-170.
- Koehler, D. and M. Chang (1999), "Search and disclosure: Corporate environmental reports," *Environment*, 41, p. 3.
- Konar, S. and M. A. Cohen (1997), "Information as regulation: The effect of community right-to-know laws on toxic emissions," *Journal of Environmental Economics and Management*, 32, 109-124.
- Kunreuther, H. and R. J. Roth, Sr. (eds.) (1998), *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States*, Washington, DC: National Academy of Sciences.
- Laplante, B. and P. Lanoie (1994), "Market response to environmental incident in Canada," *Southern Economic Journal*, 60, 657-672.
- Lees, F. P. (1996), *Loss Prevention in the Process Industry: Hazard Identification, Assessment and Control* (2nd edition), 3 volumes, Oxford: Butterworth Heinemann.
- Lewis, T. and D. Sappington (1999), "Using decoupling and deep pockets to mitigate judgment-proof problems," *International Review of Law and Economics*, 19, 275-293.
- Lopes, L. (1992), "Risk perception and the perceived public," in D. W. Bromley and K. Segerson (eds.), *The Social Response to Environmental Risk*, Kluwer Academic Publishers, 57-74.
- Magat, W. A. and W. K. Viscusi (1992), *Informational Approaches to Regulation*, Cambridge, MA: The MIT Press.
- Marschak, J. and R. Radner (1972), *Economic Theory of Teams*, New Haven, CT: Yale University Press.
- Meier, G. M. (1998), *The International Environment of Business. Competition and Governance in the Global Economy*, New York, NY: Oxford University Press.
- Miceli, T., K. A. Pancak, and C. F. Sirmans (1996), "An economic analysis of lead paint laws," *Journal of Real Estate Finance and Economics*, 12, 59-75.
- Milgrom, P. R. (1981), "Good news and bad news: representation theorems and applications," *Bell Journal of Economics*, 12, 380-391.
- Milgrom, P. R. and J. Roberts, 1986, "Relying on the information of interested parties," *Rand Journal of Economics*, 17, 18-32.
- Muoghalu, M. I., et al. (1990), "Hazardous waste lawsuits, stockholder returns and deterrence," *Southern Economic Journal*, 57, 357-370.
- Nottingham, L. (1997), "A conceptual framework for integrated risk management," The Conference Board of Canada, report no. 212-97.

- Okuno-Fujiwara, M., A. Postlewaite, and K. Suzumura (1990), "Strategic information revelation," *Review of Economic Studies*, 57, 25-47.
- Paté-Cornell, E. (1994), "Quantitative safety goals for risk management of industrial facilities," *Structural Safety*, 13, 145-157.
- Paté-Cornell, E. (1996), "Global risk management," *Journal of Risk and Uncertainty*, 12, 239-255.
- Pitchford, R. (1995), "How liable should a lender be? The case of judgment-proof firms and environmental risk," *American Economic Review*, 85, 1171-1186.
- Pollak, R. A. (1995), "Regulating risks," *Journal of Economic Literature*, 33, 179-191.
- Posner R. A. (1993), "Nobel laureate Ronald Coase and methodology," *Journal of Economic Perspectives*, 7, 195-210.
- Rechtschaffen, C. (1999), "How to reduce lead exposures with one simple statute: The experience with Proposition 65," *Environmental Law Reporter*, 10-99, pp. 10581-10591.
- Ringleb, A. H. and S. N. Wiggins (1990), "Liability and Large-Scale, Long-Term Hazards," *Journal of Political Economy*, 98, 574-595.
- Sah, R. K. and J. Stiglitz (1986), "The architecture of economic systems: Hierarchies and polyarchies," *American Economic Review*, 76, 716-727.
- Segerson, K. (2000), "Liability for environmental damages," in H. Folmer and H. L. Gabel (eds.), *Principles of Environmental and Resource Economics: A Guide for Students and Decision-Makers*, 2nd edition, Edward Elgar.
- Segerson, K. (1993), "Liability transfers: An economic assessment of buyer and lender liability," *Journal of Environmental Economics and Management*, 29, .
- Segerson, K. (1992), "The policy response to risk and risk perception," in D. W. Bromley and K. Segerson (eds), *The Social Response to Environmental Risk*, Kluwer Academic Publishers.
- Segerson, K. and T. Tietenberg (1992), "The structure of penalties in environmental enforcement: An economic analysis," *Journal of Environmental Economics and Management*, 23, 179-200.
- Shavell, S. (1993), "The optimal structure of law enforcement," *Journal of Law & Economics*, 36, 255-287.
- Sinclair-Desgagné, B. (2000a), "The power of incentives in common agency," Mimeo, CIRANO, Montréal.
- Sinclair-Desgagné, B. (2000b), "The strategic supply of precision," Mimeo, CIRANO, Montréal.
- Sinclair-Desgagné, B. (1999a), "Remarks on environmental regulation, firm behavior and innovation," Conference on Cost, Innovation and Environmental Regulation: Research and Policy Update, The Environmental Law Institute, Washington, D.C., April 30th.
- Sinclair-Desgagné, B. (1999b), "How to restore higher-powered incentives in multitask agencies," *Journal of Law, Economics & Organizations*, 15, 418-433.

- Sinclair-Desgagné, B. (1994), "La mise en oeuvre des politiques environnementales et l'organisation de la firme," *L'Actualité Économique*, 70, 211-224.
- Sinclair-Desgagné, B. and H. L. Gabel (1997), "Environmental auditing in management systems and public policy," *Journal of Environmental Economics and Management*, 33, 331-346.
- Sinclair-Desgagné, B. and C. Vachon (2000), "Dealing with major technological risks," in H. Folmer and H. L. Gabel (eds.), *Principles of Environmental and Resource Economics: A Guide for Students and Decision Makers*, Aldershot: Edward Elgar, second edition (forthcoming).
- Smith, K. (1992), "Environmental risk perception and valuation: Conventional versus prospective reference theory," in D. W. Bromley and K. Segerson (eds), *The Social Response to Environmental Risk*, Kluwer Academic Publishers.
- The Economist Intelligence Unit and Arthur Andersen (1995), *Managing Business Risks: An Integrated Approach*, New York: The Economist Intelligence Unit.
- Tietenberg, T. and D. Wheeler (2000), "Empowering the community: Information strategies for pollution control," to appear in H. Folmer, H. L. Gabel, S. Gerking and A. Rose (eds.), *Frontiers of Environmental Economics*, Cheltenham, U. K.: Edward Elgar.
- Tirole, J. (1999), "Corporate governance," 1998 Presidential address to the Econometric Society.
- Verrecchia, R. E. (1983), "Discretionary disclosures," *Journal of Accounting and Economics*, 5, 179-194.
- Viscusi, W. K. (1983), *Risk by Choice: Regulating Health and Safety in the Workplace*, Cambridge, MA: Cambridge University Press.
- Warner, Sir Frederick, et al. (1992), *Risk: Analysis, Perception and Management*, London: Royal Society.
- Williamson, O. E. (1985), *The Economic Institutions of Capitalism*, New York: The Free Press.

Liste des publications au CIRANO *

Cahiers CIRANO / *CIRANO Papers* (ISSN 1198-8169)

- 99c-1 Les Expos, l'OSM, les universités, les hôpitaux : Le coût d'un déficit de 400 000 emplois au Québec — Expos, Montréal Symphony Orchestra, Universities, Hospitals: The Cost of a 400,000-Job Shortfall in Québec / Marcel Boyer
- 96c-1 Peut-on créer des emplois en réglementant le temps de travail? / Robert Lacroix
- 95c-2 Anomalies de marché et sélection des titres au Canada / Richard Guay, Jean-François L'Her et Jean-Marc Suret
- 95c-1 La réglementation incitative / Marcel Boyer
- 94c-3 L'importance relative des gouvernements : causes, conséquences et organisations alternative / Claude Montmarquette
- 94c-2 Commercial Bankruptcy and Financial Reorganization in Canada / Jocelyn Martel
- 94c-1 Faire ou faire faire : La perspective de l'économie des organisations / Michel Patry

Série Scientifique / *Scientific Series* (ISSN 1198-8177)

- 2000s-23 Environmental Risk Management and the Business Firm / Bernard Sinclair-Desgagné
- 2000s-22 Temporal Aggregation of Volatility Models / Nour Meddahi et Éric Renault
- 2000s-21 Le projet Harmonie / Richard Landry et Suzanne Rivard
- 2000s-20 Towards an Innovation Intensity Index: The Case of CIS 1 in Denmark and Ireland / Pierre Mohnen et Marcel Dagenais
- 2000s-19 Rolling-Sample Volatility Estimators: Some New Theoretical, Simulation and Empirical Results / Elena Andreou et Eric Ghysels
- 2000s-18 Confidence Regions for Calibrated Parameters in Computable General Equilibrium Models / Touhami Abdelkhalek et Jean-Marie Dufour
- 2000s-17 Markovian Processes, Two-Sided Autoregressions and Finite-Sample Inference for Stationary and Nonstationary Autoregressive Processes / Jean-Marie Dufour et Oliver Torrès
- 2000s-16 Exact Tests for Contemporaneous Correlation of Disturbances in Seemingly Unrelated Regressions / Jean-Marie Dufour et Lynda Khalaf
- 2000s-15 Simulation Based Finite and Large Sample Tests in Multivariate Regressions / Jean-Marie Dufour et Lynda Khalaf
- 2000s-14 Les obstacles à l'innovation dans les industries de services au Canada / Pierre Mohnen et Julio Rosa
- 2000s-13 Finite Sample Inference Methods for Simultaneous Equations and Models with Unobserved and Generated Regressors / Jean-Marie Dufour et Joanna Jasiak

* Vous pouvez consulter la liste complète des publications du CIRANO et les publications elles-mêmes sur notre site Internet à l'adresse suivante :