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AN EMPIRICAL STUDY OF ENVIRONMENTAL COST DRIVERS

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Abstract

This paper draws on Environmental Management Accounting (EMA) literature and cost driver theory to study the nature and role of environmental cost drivers. More specifically, two types of operations related to environmental protection were empirically examined: the removal of asbestos from buildings and soil remediation. Findings from a series of case studies are presented and discussed. The paper contributes to existing literature in three ways: (1) by testing the adaptability of cost drivers typologies in a non-traditional, non-industrial setting (2) by proposing a more dynamic vision of the cost of social and environmental responsibility of the firm, and (3) by shedding light on the complex interrelationships of environmental cost drivers.

Keywords: Environmental Management Accounting, Cost Driver, Social & Environmental Responsibility.

Résumé:

Reposant sur le cadre de l'EMA (*Environmental Management Accounting*) d'une part, et sur la littérature relative aux inducteurs de coûts d'autre part, cet article s'intéresse aux caractéristiques et aux rôles des inducteurs de coûts environnementaux. Au travers d'études de cas menées sur des opérations de désamiantage et de dépollution des sols, cette recherche a permis (1) de tester les typologies des inducteurs de coûts dans des situations non conventionnelles et non marchandes, (2) de proposer une vision plus dynamique du coût de la responsabilité sociale et environnementale des entreprises, et (3) de mettre au jour les interactions complexes existantes entre les inducteurs de coûts environnementaux.

Mots clés : EMA, inducteurs de coûts, RSE.

INTRODUCTION

Since the 1970s, the subject of environmental accounting generates numerous debates within our scientific community. During the various stages structuring the notion of environmental accounting, the phase of formalization of this instrumentation began in the 1990s (Gray, 2002). In France, the Accounting National Council (“Conseil National de la Comptabilité”) sketched, from 1980, the beginnings of an environmental balance sheet. But it is only in 1996 that the Order of the Chartered accountants (“Ordre des Experts Comptables”) proposes a classification of the environmental allowances or still that the first work on “green” accounting is published (Christophe, 1995). At the European level, it is as well during this decade that the System of Economic and Environmental Accounting (SEEA) is created.

These attempts of instrumentalisation of the social and environmental responsibility of the company constitute a means to bring a quantified "proof" calculated of the commitment (Burnett and Hansen, 2007; Lehman, 1999), to perfect the decision process (Kitzman, 2001), to legitimize the organization towards its environment (Cho and Patten, 2007; Larrinaga-Gonzalez and Bebbington, 2001) or still to improve the performance of the organization (Clarkson et al. 2008; Cormier and Magnan, 2007).

However, if they symbolize a necessary evolution of accounting to integrate the environmental and societal dimensions, these accounting systems also face numerous challenges. If an easy consensus exists as soon as it is a question of saving the planet, the situation becomes more difficult when it comes to pay the price or to assign the efforts to the various stakeholders. But how much costs the protection of our environment and on what depend these costs? What are the factors that drive environmental costs?

From these two questions, we developed a research around two major environmental problems: soil remediation and asbestos removal from buildings. On these two problems, the costs depend on such a large number of factors or “cost drivers” that it seems important to identify and to analyze better the underlying cause-and-effect relationships. The necessary financial sums to protect the environment are very important and have to be the object of massive budgetary funding. But these costs are not given data; they are constructs which can be more or less important according to the choices made and the options retained. It is thus important to wonder about the dynamics of these committed costs.

The problem of the cost of environmental protection, and more widely of environmental accounting, has already been the object of several researches. The ensuing Environmental Management Accounting (EMA) framework supplies a useful approach to understand, measure and report environmental costs. However, our contribution tries to go beyond, in order to understand environmental cost drivers and their interrelationships so as to be able to manage them efficiently.

The rest of the paper is organized as follows. Section 1 defines Environmental Management Accounting. Section 2 presents the various streams of literature on the concept of cost driver. Section 3 describes the typology of environmental cost drivers which we used for our empirical study. Section 4 deals with the methodological aspects. Section 5 presents the main results stemming from our case studies. Finally, section 6 discusses these results.

1. ENVIRONMENTAL MANAGEMENT ACCOUNTING

The integration of environmental problems in the management of companies came along with a crucial debate concerning the cost of this integration. The question being: How much costs the protection of environment? This role of cost calculation was logically devolved to the accounting function. But to calculate an environmental cost puts difficulties, both on technical and on cognitive aspects. Furthermore, the variety of accounting forms (financial, managerial) brings the question to know where to place the calculation of environmental costs.

Bartolomeo et al. (2000) show that there are within organizations two accounting systems for environmental aspects. They build their reasoning on the classic dichotomy based on the type of accounting information users: internal vs. external users. For internal users such as managers, the system used to manage environmental costs is called “Environmental Management Accounting” (EMA). For external users such as shareholders, the system used is called “Environmental Accounting” (EA). In the absence of a well developed framework, several academic and professional initiatives have tried to clarify the notion of EMA. Therefore, several definitions of this concept can be found as shown in Table 1 below.

From table 1 it appears that the EMA concept is wide and rather loosely defined. This ambiguity comes from the fact that EMA and EA are not always easily distinguished as they share some common topics. Another source of ambiguity is the nature of the information to be measured, which is in itself quite ambiguous.

Table 1: Definitions of EMA (adapted from Burritt and Saka, 2005)

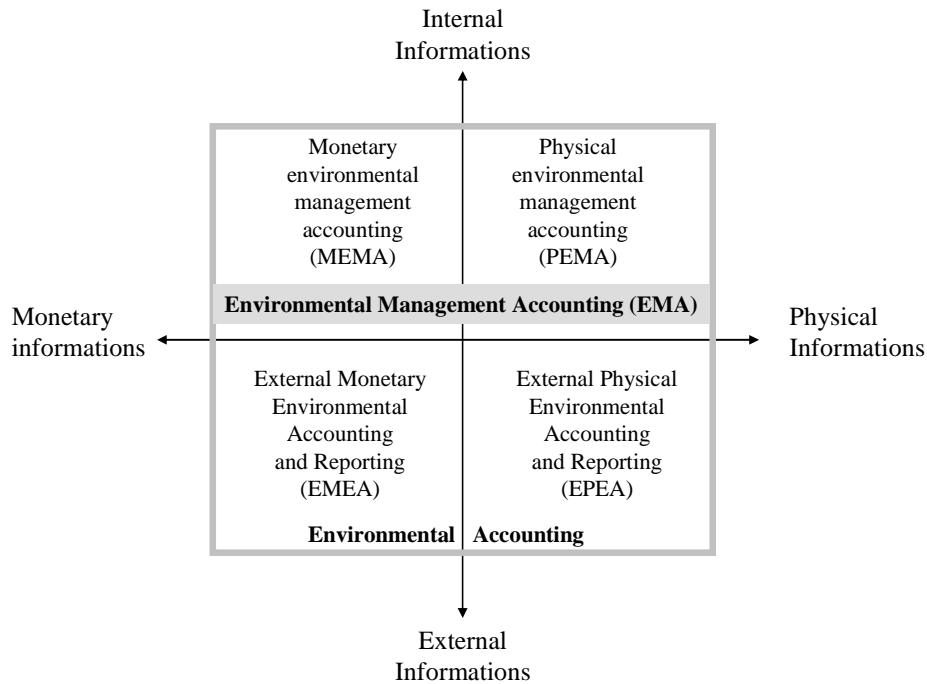
Sources	Definitions
Academic	
Graff et al. (1998)	Environmental management accounting is the way that businesses account for the material use and environmental costs of their business. Materials accounting is a means of tracking material flows through a facility in order to characterize inputs and outputs for purposes of evaluating both resource efficiency and environmental improvement opportunities. Environmental cost accounting is how environmental costs are identified and allocated to the material flows or other physical aspects of a firm's operations.
Xiaomei (2004)	It is a new branch of accounting which is under the direction of sustainable economic development goal, using the basic accounting theory and method to recognize measure and report the environmental management system and the environmental impact of economic activities of a business.
Schaltegger and Burritt (2000)	EMA is defined in a narrower sense to include only the environmentally induced financial aspects of accounting that help managers to make decisions and be accountable for the outcome of their decisions.
Bennett and James (1998)	The generation, analysis and use of financial and non-financial information in order to optimise corporate environmental and economic performance and to achieve sustainable business.
Jasch (2003)	EMA, Environmental management accounting represents a combined approach which provides for the transition of data from financial accounting, cost accounting and material flow balances to increase material efficiency, reduce environmental impact and risk and reduce costs of environmental protection.
Professional	
International Federation of Accountants (2005)	[Environmental management accounting is] the management of environmental and economic performance through the development and implementation of appropriate environment-related accounting systems and practices. While this may include reporting and auditing in some companies, environmental management accounting typically involves life-cycle costing, full cost accounting, benefits assessment, and strategic planning for environmental management.
United Nations (2001)	Environmental management accounting serves as a mechanism to identify and measure the full spectrum of environmental costs of current production processes and the economic benefits of pollution prevention or cleaner processes, and to integrate these costs and benefits into day-to-day business decision-making.

For that reason, Burritt et al. (2002) integrate the notions of monetary information and physical information to refine the concepts of EMA and EA. For these authors, monetary information concerns “environmentally related impacts on the economic situation of companies”, while the physical information concerns “company related impacts on environmental systems” (Burritt et al., 2002, p. 41). Their reasoning ends in the positioning of EMA according to two predefined dimensions: “users of the information” and “nature of the information” (see figure 1 below).

The present paper addresses issues and questions that belong to Monetary Environmental Management Accounting (“MEMA”). According to Burritt et al. (2002), MEMA “deals with environmental aspects of corporate activities expressed in monetary units and generates information for internal management use (e.g. costs of fines for breaking environmental laws;

investment in capital projects that improve the environment). In terms of its methods MEMA is based on conventional management accounting that is extended and adapted for environmental aspects of company activities”.

Figure 1: Environmental accounting systems framework (Burritt et al., 2002)



In conclusion, academic and professional works on the EMA concept have attempted to explain its scope, peculiarities, various dimensions and characteristics, and finally its borders with other forms of accounting. More particularly, studies emanating from professional organizations have tried to propose systems or typologies allowing to identify and to classify environment-related costs (Jasch, 2003; Gale, 2006). Nevertheless, Environmental Management Accounting research has so far remained almost silent on the question of environmental cost drivers. For that reason, we think that the cost driver literature is the most suited to answer the research questions raised in the introduction of the paper. The next section will present such a literature.

2. COST DRIVER LITERATURE

As noted by Banker and Johnston (2007), there is no single, widely accepted and unifying theory or taxonomy of cost drivers. In a recent review of the cost driver literature, these two authors identify at least three streams of research dealing with this concept, explaining that “the early publications in the management accounting research literature making the case for

understanding cost driver relationships in greater detail and complexity [...] included Kaplan (1983, 1984), Miller and Vollmann (1985), Cooper & Kaplan (1987), Shank (1989), and Shank and Govindarajan (1989) who drew particularly upon Porter’s (1985) strategic cost analysis and management framework” (Banker and Johnston, 2007, p. 532). Table 2 below presents three major cost driver taxonomies stemming from these various research streams.

Table 2: Comparison of cost driver taxonomies (Banker & Johnston, 2007, p. 533)

Porter (1985)	Riley (1987)	Cooper & Kaplan (1998)
Scale	<i>Structural drivers</i>	<i>Manufacturing stage of value chain</i>
Learning and spillovers	Scale	Unit-level
Capacity utilization	Scope	Batch-level
Linkages between activities across value chain (within firm, across extended value chain)	Experience	Product-sustaining
Linkages with business units within the firm	Production technology, across the value chain	Facilities-sustaining
Timing (first/late movers)	Product line complexity	<i>Rest of firm value chain</i>
Policy choices (product design and mix (scope), service levels, investments, delivery times, distribution channels technology, materials quality)	<i>Executorial drivers</i>	Customer-sustaining
Geographic locations	Workforce commitment to continuous improvement	Product-line sustaining
Institutional factors (regulation, tariffs, unionization)	Quality management	Brand-sustaining
	Capacity utilization	Channel-sustaining
	Plant layout efficiency	Location-sustaining
	Product design configuration	Corporate-sustaining
	Linkages with suppliers and customers (extended value/supply chain)	<i>Extended value/supply chain</i>
		Vendor-sustaining

Porter (1985, p. 63), articulating a strategic management framework grounded in industrial economics theory, was one of the first to use the concept of “cost drivers”, defined as the structural determinants of the costs of organizational activities. According to Porter, the degree of control which a firm possesses on its activities’ cost drivers is variable. The cost “position” of a firm depends on the behavior of costs in each of the value-creating activities performed. In turn, the behavior of costs depends on a certain number of structural factors which Porter calls “cost drivers”. Several drivers can combine in order to determine the cost of a given activity. The nature of the most important cost drivers can vary across firms and industries, especially if the value chains are different. The relative position of a firm with regard to the costs of a given value-creating activity depends on the way it stands in the face of its most important cost drivers.

Drawing on the work of Porter (1985), Riley (1987) proposes a typology distinguishing two categories of cost drivers: “structural” drivers and “executorial” drivers. The first category - structural drivers - is inspired by industrial organization literature. In this perspective, the firm has to make at least five strategic choices concerning its economic structure, these choices

being determinants of the company's cost level and structure. These five choices deal with scale, scope, experience, technology, and complexity.

The second category corresponds to executional cost drivers. As their name indicates it, these drivers represent the way a firm "executes" more or less efficiently its operational activities. While the structural drivers are not necessarily correlated in a positive and linear way with the firm's performance (there may be diseconomies of scale for example), executional drivers are. In Riley's (1987) typology, these include work force involvement and participation, Total quality management, capacity utilization, plant layout efficiency, product configuration, and the exploitation of linkages with suppliers and/or customers, per the firm's value chain.

As Banker and Johnston (2007, p. 534) relate: "Building upon their own observations, as well as those of Miller & Vollmann (1985), Cooper & Kaplan (1987) began to build a model in which the characteristics of products and production processes, especially product line diversity and production process complexity, instead of, or in addition to, output volumes, cause transactions or activities, which in turn cause or drive manufacturing overhead costs." This model took the names of Activity-Based Costing (ABC) and Activity-Based Management (ABM). Later on, Cooper and Kaplan (1991) extended ABC/M to other stages of the value chain such as marketing, selling and distribution, R&D and so on (see table 2).

The vocabulary used in the initial ABC literature can be seen as a little bit confusing regarding the concept of cost driver. Cooper and Kaplan (1998) addressed this issue later on by using the term "process driver" instead of "cost driver" so as to distinguish it from "resource" and "activity" drivers. The two authors justified this change in vocabulary with the following arguments: "The CAM-I model introduced a process view as a horizontal axis at the activity level. The process view introduces a different type of cost driver, which we shall call a process driver. Process drivers help to explain the quantity of resources, and hence the cost, required to perform an activity. [...] Process drivers relate to the efficiency of performing the activity. Any activity could have several process drivers associated with it." (Cooper & Kaplan; 1998, p. 280)

Approximately at the same time of the development of the ABC model, Shank & Govindarajan (1989) defined what they called "strategic cost analysis" as the process of 1) defining a firm's value chain and assigning costs and assets to its value-creating activities, 2) investigating the cost drivers "regulating" each activity, and 3) using cost behavior

information to analyze alternative means for achieving competitive advantage, by either controlling cost drivers or reconfiguring the value chain.

Specifically with respect to cost driver analysis, Shank (1989) and Shank & Govindarajan (1993) argued that understanding cost behavior implies understanding “the complex interplay of the set of ‘cost drivers’ at work in any given situation (Shank, 1989, p. 55) – as opposed to the independence and mutually exclusive partitioning reflected in traditional cost accounting systems and design of ABC systems emerging at the time.

Shank (1989, p. 50) defines “Strategic Cost Management” (SCM) as “the managerial use of cost information explicitly directed at one or more of the four stages of the strategic management cycle”. For him, SCM results form a blending of three underlying themes that are each taken from the strategic management literature: value chain analysis, strategic positioning analysis and cost driver analysis. Regarding cost driver analysis in SCM, “it is acknowledged that cost is caused, or driven, by many factors that are interrelated in complex ways. Understanding cost behavior means understanding the complex interplay of the set of ‘cost drivers’ at work in any given situation.” (Shank, 1989, p. 55)

Like Riley (1987), Shank makes a distinction between structural and executional cost drivers when he states that “cost is a function of strategic choices about the structure of how to compete and managerial skill in executing the strategic choices” (Shank, 1989, p. 62). Aware that any typology of cost drivers is subject to discussion regarding the drivers it lists and the one it does not, Shank synthesizes the main issues of cost driver analysis in four points. First, for strategic analysis, volume is usually not the most useful way to explain cost behavior. Second, what is more useful in a strategic sense is to explain cost position in terms of the structural choices and executional skills which shape the firm’s competitive position. Third, not all the cost drivers are equally important all the time, but some of them are very probably very important in every case. And four, for each cost driver there is a particular cost analysis framework which is critical to understanding the positioning of a firm (Shank, 1989, p. 58).

Embracing these remarks, the present paper can be seen as an attempt to develop a particular framework for environmental cost analysis and to identify the most important environmental cost drivers. Drawing on the different streams of cost driver literature the first step in our empirical research was to develop a typology of environmental cost drivers. The next section will present such a typology.

3. A TYPOLOGY OF ENVIRONMENTAL COST DRIVERS

Anderson (2007, p. 493-494) notes that “much of the literature on sustainability concludes that a necessary condition for strategic management of environmental and social costs is increased visibility of the full costs (and benefits) of a firm’s operations.” However, Joshi et al. (2001) provide strong evidence showing that most cost accounting systems obfuscate the magnitude of costs associated with environmental compliance. Moreover, as noted in the introduction of this paper, Environmental Management Accounting literature is almost silent on the topic of environmental cost drivers.

In order to address the research questions raised in the introduction of this paper, and in the absence of previous research on the same topic, we have developed our own typology of environmental cost drivers. The starting point of this process was the typology of Porter (1985) further refined by Riley (1987) and Shank and Govindarajan (1993) as discussed in the previous section of the paper. However, as noted by Bjornenak (2000) in his study of the cost drivers of Norwegian public schools, these refinements were all based on inductive analyses of private sector case studies, which may explain the exclusion of institutional factors from their list of cost drivers. Hence, the lists and groupings developed so far in the cost driver literature were not found to be fully compatible with the context of environmental costs.

Table 3: Proposed typology of environmental cost drivers

Cost driver category	Cost driver name (our typology)	Cost driver name in Porter’s (1985) typology	Cost driver name in Riley’s (1987) typology
Structural cost drivers	Scale	Economies of scale, interrelationships with other business units	Scale (including horizontal integration)
	Scope	Level of vertical integration	Scope
	Experience	Learning & spillovers	Experience
	Production technology	NA	Production technology
	Service line complexity	Policy choices	Product line complexity
	Location	Location	NA
Executorial cost drivers	Work force involvement	Policy choices	Work force involvement
	Linkages along the extended value chain (suppliers, customers and within the firm)	Linkages within the value chain, with suppliers & with distribution channels	Linkages with suppliers and/or customers, within the firm
	Timing of the job ¹	Timing	NA
	Discretionary policies	Policy choices	NA
Institutional cost drivers	Legislation	Institutional factors	NA
	Market development	NA	NA

¹ In our study, the relevant cost object is the “job” (i.e. asbestos removal jobs or soil remediation jobs) rather than the product.

The refinement shown in table 3 above was found to be more useful. The list is informed by the cost driver concept developed by Porter (1985) and the subsequent refinements in the SMA literature (see Section 2). However the adoption of the concept is adjusted to the context discussed, i.e. environmental costs and more specifically soil remediation and asbestos removal from buildings.

Structural drivers are related to deliberate strategic choices made by the firm in several areas:

- Scale: How big an investment to make in resources such as manufacturing or R&D;
- Scope: Degree of vertical integration. Horizontal integration is more related to scale;
- Experience: How many times in the past the firm has already done what it is doing;
- Production technology: What technologies are used at each step of the value chain;
- Service line complexity: How wide a line of products or services to offer to customers;
- Location: Location of the company in relation with the performed jobs' location.

Executional drivers are related to how efficiently the firm is executing its activities:

- Work force involvement: Work force commitment to continual improvement;
- Linkages along the extended value chain, i.e. linkages with suppliers, with distribution channels/customers and between the internal activities of the firm;
- Timing of the job: depending on capacity utilization of the whole industry (match between offer and demand at industry level), prices charged for a job may vary;
- Discretionary policies regarding all other executional issues within the firm.

Finally, institutional drivers are related to legislation aspects on the one hand and to market development (number of companies, level of competition, etc.) on the other hand.

4. METHODOLOGY

To answer our research question, we first identified five major environmental problems which companies face today: asbestos removal, the dismantling of ships, soil remediation, high environmental quality and environmental management systems. Nevertheless, we chose to focus only on the problems of asbestos removal and soil remediation for three reasons. First, the empirical material for these two problems is available in greater volume than for the other themes, notably because of the reproduction of this kind of operations over the past few years. Secondly, these two types of operations present interesting similarity in the sense that they are

environmental problems which come downstream to life cycles because they concern damages already done to the environment (contrary to high environmental quality and environmental management systems which concern essentially the preventive aspect). Finally, the nature of these operations is convenient for a study on cost drivers because the calculation of the costs and the identification of the drivers are facilitated by the job/project organization.

In order to perform the study, we used the case study method. For the removal of asbestos, we chose operations of different complexity level: Paris-Jussieu University, a tower of big height, a hospital still in service during the removal job as well as more simple jobs on disused buildings. In total, seven operations of asbestos removal were studied. For the remediation of soils, we concentrated on pyrotechnic pollutions (22 cases of grounds polluted by the two World Wars) and chemical pollutions (two grounds polluted chemically). Table 4 below summarizes the various case studies performed for this research.

Throughout the field work, we adopted an exploratory and qualitative methodology based on interview guides and questionnaires built after an attentive study of the public data on such operations. In every case study, we had access to detailed cost calculations. Unfortunately, this information were always presented according to specific formats thus not allowing an immediate comparison across the cases. Our approach aimed essentially at the description and at the interpretation of the processes which end in the construction of an environmental cost. While doing so, an identification of the main environmental cost drivers was made possible thanks to the various interviews performed.

For every case, the method of data collection was identical and followed the following steps: familiarization with the problem, writing of a questionnaire sent before the interview, interview with one or several persons in charge of the operation, collection of written information on the costs, write-up of the case and its submission to the interviewees, comparison of the cases. In the end, the variety of the case studies allowed us to obtain very rich data and interpretations regarding environmental costs and their drivers.

Table 4: Summary of case studies performed

	Asbestos removal	Soil remediation
Number of case studies	7 jobs of various complexity + analysis of the available literature	24 case studies + analysis of the available literature
Nature of the case studies	Paris-Jussieu University campus; A tower of big height; A hospital still in service during the removal job; Four buildings with a simple structure (low complexity removal jobs)	Soils pyrotechnically polluted during the two World Wars (22 cases) Soils chemically polluted (2 cases)

5. RESULTS

In this section, we will present the main results of our empirical study by category of cost drivers, i.e. structural, executional and institutional drivers.

5.1. Structural drivers

Six structural drivers were retained in our typology of environmental cost drivers: scale, scope, experience, technology, service line complexity and location.

5.1.1. Scale

This cost driver concerns economies of scale. Let us note first of all that the size of the operation is indeed an evident explanatory factor of the total cost of the project. However, the relevant question is: How does the size of the operation impact the cost per square or cubic meter cleaned up? The data which we collected seem to show a slight positive effect even if the interviews did not mention it.

A first effect of distribution of the fixed costs over a larger volume explains this decline. So for example, in the case of the removal of asbestos, every construction site must be equipped with sophisticated showers, whatever the size of the operation. So, the bigger the building will be, the more the part of this fixed cost will decrease in the total cost per square meter cleaned up. The same type of effect is observable in the case of soil remediation. The data collected indicate that for a surface of 20,000 m² the cleanup cost is about €2 per m². For a surface of 60,000 m², the cost decreases to €1.35 per m² while for a surface of less than 200 m² the cost jumps to €90 per m². These savings are due however essentially to capacity optimization issues and to the spreading of fixed costs over a more important volume.

5.1.2. Scope

This driver makes reference, in our example, to the impact on the operation's costs of the variety of the pollutions found on a site. It emerges from our study that the more important the variety of the buried pyrotechnics/chemicals or the more the asbestos to be treated is of different nature, the higher will be the total cost of the operation. Moreover, we observed very little synergies stemming from the treatment of a larger number of pollutants.

5.1.3. Experience

This cost driver insists on the learning effect consecutive to the realization of several successive cleanup operations. The markets of soil remediation and asbestos removal being at present under construction in France (see §5.3.2), experience seems to have little effect on the cost of the operations studied in this research.

The markets of asbestos removal and soil remediation are young markets in the course of institutionalization. On the chemical cleanup market, the professional union accounts for 30 companies distributed on the French territory and a total number of 1,500 employees. The labor is quite highly qualified because this type of cleanup presents characteristics in connection with the training of engineers. The pyrotechnic cleanup market groups together less than ten companies in France. The qualified labor comes mainly from the military sector. On the asbestos removal market, there are just a few companies because of the necessary qualifications. It can even be considered as an oligopolistic market.

In front of the relative youth of these markets, the impact of experience on environmental costs is threefold. At a first level, companies without experience need time to integrate statutory standards and the related legislation into their operating processes. At a second level, companies without experience tend to propose lower prices.

Finally, experience seems to play a main role in the preparation phase of the operation, as shown in the Balard case study where a particularly competent subcontractor was able to substantially lower costs thanks to its past experience of similar projects.

5.1.4. Technology

Technology is a very important environmental cost driver in the cases of asbestos removal and soil remediation. Upstream to the operation, in the case of asbestos removal, the choice of encapsulate the Balard building allowed to manage unpleasant surprises such as the discovery of asbestos unexpected from the beginning. On the other hand, on the sites of Paris-Jussieu University and Bégin hospital, the engineers did not use the same technique, which lowered costs but at the risk of finding unexpected asbestos.

Regarding soil remediation, the initial stage of soil analysis can be handled through three different processes involving different technologies: magnetometer, electromagnetism and

georadar imaging. The first two methods allow a summary detection of the metallic masses buried in the ground while georadar imaging allows a sharper characterization of the metallic masses found. The technology used to perform the diagnosis has a strong influence on the cost of the operation. Georadar imaging is the most expensive solution in terms of diagnosis but may reduce the costs of operating the later stages of the soil remediation.

During the operation, and even if the modalities of execution are strongly framed by the law, the cost is mainly driven by the environment of the operation. For the removal of asbestos, the cost will be different whether the job is made on a completely empty or disused building (Balard case) or on a building that (partly) stays in functioning (Paris-Jussieu University and Begin hospital case studies). A building that is still (partly) in service poses several logistic problems such as waste handling and disposal or simply access to the building.

The case study of the Begin hospital shows the important role that the direct environment of the job can play (tranquility of the patients, access to the car park, information systems that must be kept in working order). This variation in the cost results from the cohabitation of two potentially contradictory objectives: continued use of the building and its cleanup. As an interviewee of the Balard case told us: “An asbestos removal job, it’s 75% logistics and 25% works”. We have observed the same potential impact of an operation’s environment in the cases of soil remediation studied.

Downstream to the operation, technology choices may concern, for example, the final handling and disposal of toxic waste. For asbestos, waste can be buried or vitrified. Regarding soil remediation, ammunitions can be treated in situ or on another site. The choices made have a clear impact on the cost.

5.1.5. Service line complexity

This driver analyzes the complexity of the operations of asbestos removal and soil remediation. We identified three main sources of complexity: the variety of pollutants, the conditions of the operation and the uncertainty of pollutants.

Variety of pollutants: For soil remediation, the intensity of the pollution explains partially the cost of the operation. This intensity results from the type of pollutant, from its concentration, from its seclusion and from the nature of the ground. As one interviewee mentioned: “It is very difficult to estimate the cost of a cleanup because every construction site is really very

particular. It depends on local conditions, on the nature of the pollution, and on quantities of ammunitions expected to be found.”

Conditions of the operation: For the removal of asbestos, the complexity results from the building’s characteristics. Is it occupied or not? How big is the height of the building? Is it necessary to plan a rehousing? All these characteristics have a big impact on the cost.

Uncertainty of pollutants: For the removal of asbestos, the uncertainty comes from the unpredictable nature of the building and the random distribution of the pollutant. Furthermore, the asbestos can be located in places that are not accessible by workers, inside the building or outside on more or less crisp facades. These uncertainties can have a big impact on the cost. For example, if the asbestos is on the facades of the building, it will be necessary to build an outside structure on which the seclusion will rest.

For the remediation of soils, the diagnosis stage does not allow to identify exactly all the targets to be cleaned up. So, during the operation, new targets will appear, new treatments will be made and the global cost of the operation will increase. Furthermore, the reaction of the ground during the operation is particularly difficult to forecast. As one interviewee explained: “The difficulty in the methodological approach comes from the understanding of the complex system that constitutes the soil. It is a complicated reactor which possesses a dynamic variability, with regard to pollutants. It is necessary to understand the soil as a living system that evolves over time and to adopt a long term vision of it”.

5.1.6. Location

This last structural driver describes the impact of the location of the cleanup operations on their costs. At first glance, this driver seems to have no impact. Indeed, the studied cases are static, contrary to the dismantling of ships for example. However, the operations of waste treatment could take place outside the polluted site. As indicates the following excerpt from an interview, this is rarely the case because the cost of this operation is not significant: “The cost of the cleanup of a ground also raises the problem of the outsourcing of certain activities like the treatment of waste. At present, we do not notice an increase of these costs, and this in spite of the evolution of the legislation, thanks to the competition between subcontractors.”

Nevertheless, by widening our perspective, location has an impact on the costs. The location of the operation, and its environment, can indeed engender important additional costs. For a

soil remediation job near a city center (as in the case of AZF), the conditions of access to the site or still for an operation of asbestos removal from an hospital, the geographical situation of the job can complicate the operations and thus increase the costs.

5.2. Executional drivers

Executional cost drivers include work force involvement, linkages along the extended value chain, timing and discretionary policies.

5.2.1. Work force involvement

The intensity of the work does not seem to count much in the explanation of costs. The work force can work more or less fast but their efficiency is very constrained by regulations. The entrance and the exit of the decontamination hatch on an asbestos removal site can take several hours. Additional to that is the hardness of the work. Not much time is left to work effectively. Besides, the workers are paid the minimum legal wage. When all these factors are taken into account, there is not much room left for cost variations or cost savings.

5.2.2. Linkages along the extended value chain

This driver makes reference to the sequencing of activities within the value chain and their interrelationships. In both type of operations, asbestos removal and soil remediation, various types of actors are going to influence each other one after the other as the job progresses.

For the removal of asbestos, several actors intervene: project owner, project owner delegate, the firm in charge of the diagnosis, operators and subcontractors. The work of the actors intervening at the beginning of the value chain is going to impact the cost of the operations performed afterwards. The Balard asbestos removal case is a good example of that phenomenon. A decision had to be made whether encapsulating the whole building or not. In the end, it was decided to do so thanks to the advice of the delegated project owner.

Other similar examples were found. The risk of a badly realized diagnosis often translates into significant additional cost because the envisaged solutions show themselves unsuitable, or because more labor hours are necessary in the end to remove some undetected asbestos.

5.2.3. Timing

Timing is an important cost driver both for the removal of asbestos and soil remediation. Its impact is twofold. First, timing is interrelated with the market. As the number of available subcontractors is very small, a bad timing of the job (i.e. during a shortage of service capacity) will result in a longer cycle time and increased costs.

Second, timing is associated with the duration of the job. For the removal of asbestos, the cost of the move, of the rehousing and of the immobilized equipment entail an important additional cost. Furthermore, as already mentioned above, the schedule of the job can undergo important changes because of unforeseen difficulties. For example, some asbestos not identified at first can be found and their handling will slow down the overall project. The building can so remain immobilized during several years.

For the remediation of soils, the negotiation between the various actors concerned by the area and its treatment lengthens considerably the deadlines. Furthermore, the publication of the decree number 2005-1325 of October 26th, 2005 and the publication of the orders of January 23rd, 2006 inferred a strong increase of the processing times of the pollution. Finally, a ground can remain polluted because its cleanup cost is not bearable for its owner. For example, the cleanup of groundwater can last several years up to 10 or even 20 years.

Indirectly, “timing”, as an important environmental cost driver, highlights the practical difficulties of implementing the EMA framework in practice. Indeed, the formalizations proposed by the EMA framework do not clearly state these opportunity costs driven by the timing of the operations.

5.2.4. Discretionary policies

The political choices influence strongly the cost of the operations. Even if these markets are strongly framed by the law, the intervening actors have some room to maneuver. This freedom can explain part of the variation of the total cost. The first question which arises is the one to make or not to make the cleanup. Regarding the removal of asbestos, the legislation can oblige to remove all the asbestos, in particular when the building is sold. However, if the building is not sold, the actors can choose to seal the asbestos. This latter solution is cheaper and can prove to be safer.

The second question concerns the degree of cleanup: Is it necessary to clean up completely or only partly? The question is justifiable in the case of the presence of asbestos in glues of stone floor. Such a case does not present immediate danger. However, during every future maintenance operation, if some asbestos remains, precautions that amount to a removal of the asbestos will have to be taken, thus inflating the maintenance costs. Some cost savings can thus be made on one-shot asbestos removal jobs, but these savings will be negatively compensated by additional maintenance costs. These hard-to-estimate additional costs are completely attributable to the asbestos removal job, but they will appear only a long time after the end of the operation. For soil remediation, the degree of cleanup depends strictly on the future use of the site. For a pedestrian usage, the cleanup will be made on a less important depth than for a road usage. In the same way, the concentrations of pollutants will have more important thresholds for a landscaped usage than for a urban one.

The third question concerns the stakeholders of the operation. For example, the asbestos removal from Paris-Jussieu University is in the center of numerous stakeholders' concerns. These stakeholders include a Minister that graduated from this university, world-renown professors, an "anti-asbestos committee", etc. In a general way, the presence of numerous stakeholders with divergent goals can stop the project for a few months and increase its costs.

5.3. Institutional drivers

This latter category includes two cost drivers: legislation and market.

5.3.1. Legislation

As we have already mentioned it, asbestos removal and soil remediation jobs are heavily constrained by regulations.

The legislation regarding the removal of asbestos has changed a lot and will doubtless continue to evolve a lot in the future. These regulations are plentiful and prescribe the behavior to be adopted, i.e. the precautions required to clean up. The main texts that constitute the French legal framework of this activity are the following ones: the order of January 2nd, 2002, that of August 22nd, 2002, the public health asbestos code (diagnosis and location), the order of March 6th, 2003 (analysis of samples), the standard NFX 46-020 (location prior to removal job), the decree 2006-1072 of August 25th, 2006 (the "Asbestos Technical File"), the 1st chapter of the title III of the book II of the employment code of laws, the section number

5bis entitled “particular measures of protection against asbestos related risks”, the order of February 22nd, 2007 (compulsory qualification certificate of the executing company) and the modified order of May 14th, 1996 (demolition, withdrawal or seclusion plan).

In the same way, the legislation relative to the operations of pyrotechnic cleanup evolves continuously while balancing the precautionary principle and economic capacity. The main legal texts framing this activity in France are the following ones: the decree number 76-225 (which sets the respective attributions of Home Secretary and Minister of Defense in terms of research, neutralization, removal and destruction of ammunitions and explosives), the decree number 2003-451 and 452 of May 19th, 2003, the instruction DEF/SGA of July 28th, 2006 (relative to safety regulations that should be adopted by the military and civil staff of the Ministry of Defense during a pyrotechnic cleanup), the decree n°2005-1325 of October 26th, 2005 and the orders of January 23rd, 2006 (that fix the rules to calculate the isolation distances for pyrotechnic cleanup sites and determine the level of required knowledge and medical competencies to be held by the person in charge of pyrotechnic safety, by the site manager and by the persons that will execute the job).

5.3.2. Market

The markets of asbestos removal and soil remediation are new, under-construction markets. There are very few companies that can take care of these operations. This characteristic engenders opportunistic behavior in the relationships between customers and suppliers. Service providers thus have a true market power and potential customers are price takers. So, as any market, the market of asbestos removal is subject to the variations of offer and demand. The price charged (and hence the cost for the client) for a specific job is largely going to depend on the available offer (i.e. capacity available for the supplier). In the future, the cost of asbestos removal will depend on the evolution of the market and on the number of companies entering and quitting this market. In the end, the market of asbestos removal will eventually disappear when there will remain no more job to perform (as the use asbestos is now forbidden for the construction of new buildings).

6. DISCUSSION

Three types of contribution can be drawn from the findings of our case studies on asbestos removal and pyrotechnic pollution cleanups. The first contribution relates to cost driver theory

in general. The second contribution consists in a better understanding of the drivers of environmental and social responsibility of the firm in more dynamic perspective than in the current EMA framework. Finally, the third contribution highlights the way in which the various environmental cost drivers are interrelated.

Table 5: Overview of results

Cost driver category	Cost drivers	Impact degree (1 = weak, 3 = strong)	Cost variation factor
Structural drivers	Scale	1	Total surface or volume to be cleaned up as expressed in m ² or m ³
	Scope	NS	Diversity of pollutants
	Experience	1	Market in the process of institutionalization, still too early for any significant return of experience
	Technology	3	Technology choice has a strong impact on the diagnosis and execution stages
	Service line complexity	3	Pollutants' characteristics and complexity
	Location	2	Geographical environment of the site
Executorial drivers	Work force involvement	NS	None
	Linkages along the extended value chain	2	Degree of coordination between the various actors intervening on a site
	Timing	3	Balance between offer and demand Length of a job depends on unexpected events and goal congruence of actors
	Discretionary policies	3	Make or buy? Clean up of the whole site/pollution or only part of it? Influence of stakeholders
Institutional drivers	Legislation	3	Degree of freedom left
	Market	1	Market power of subcontractors

6.1. Contribution to cost driver theory

Our observations allow a better understanding of the relative importance of cost drivers usually presented in the literature. By leading a study in a new field (environmental costs) we indeed enrich our understanding of the cost drivers influencing a given operation. Our results allow then to widen the traditional industrial and commercial perspectives of cost calculations

The operations which we studied are highly uncertainty and visible from the public. Many interviewed people quote spontaneously the good management of the value chain, in particular the quality of the diagnosis, as an important factor allowing to reduce and to pilot better the costs in an uncertain context. The higher the uncertainty, the more crucial are the upstream phases.

The studied operations are also highly visible from the public and hence are the subject of strong pressures from the stakeholders. “Political” or discretionary cost drivers, not much taken into account so far in the cost driver literature (Bjornenak, 2000), appear in this study as the most important cost drivers. For example, in the case of asbestos removal, it is necessary to distinguish the cost of the operation strictly speaking from costs of the secondary operations which can represent much more in the end. It thus asks the question of the perimeter of the costs to be taken into account.

The CSR raise problems of performance measurement, illustrated by the notion of triple bottom line. These are still badly institutionalized practices. The less these practices are institutionalized, the higher the costs are because of the political and discretionary choices. Furthermore, for these badly institutionalized operations), cost drivers related to the development state of the market are key to explain the variation of the costs across different cleanup jobs. So, companies experienced with this type of operations are not still numerous. Besides, the market is often narrow and the few existing companies are price makers. Finally, the fact that the operation takes place in the Paris area or somewhere else is also important as there are more companies competing for jobs in the Paris area, which lowers prices.

Finally, in business sectors highly regulated in their executional process as the ones studied in this paper, some structural and executional cost drivers are of little importance. Scale and scope, for example, were not found to be playing an important role (but more observations would be necessary). Workforce involvement and job layout are highly constrained by the regulations. Also, what is striking is that the market is at the same very regulated for safety reasons and very weakly institutionalized because of its youth.

In the end, the cleanup operations studied in this paper are quite different from classic industrial settings, which could thus require the development of new cost drivers typologies based on the characteristics of the operations under study.

6.2. Contribution to social & environmental responsibility theory

This paper is theoretically anchored in the EMA framework. Indeed, this study addresses one of the objectives assigned by Gray et al. (1993) to EMA, i.e. to identify in a autonomous way environmental costs and revenues the environmental outside the traditional financial

accounting system. More exactly, our aim was to identify cost drivers in order to shed light on the complexity of a standardization process of environmental cost.

Our data allow a critical discussion of the accounting approaches of the social and environmental responsibility of the firm. In spite of the interest of an environmental costs classification by the EMA framework, such an approach remains static. Only a few categories of costs are accounted for, whose environmental nature does not really raise problem. But as shown in our study, this vision is too positivist and does not take into account some very important costs because of their ambiguous link with the environment. For example, the Canadian Order of Chartered Accountants suggests classifying environmental costs into five categories (Farley et al., 1997): evaluation, prevention, correction, control and image. Does the use of this typology allow assessing exactly the perimeter of an environmental cost? Our case studies indicate that several costs would not easily fill into this typology while they are directly linked to the cleanup costs. Opportunity costs are examples of such costs: an unusable building or ground, or a decrease in efficiency due to relocation engenders additional costs rarely integrated into the classic perimeter of the environmental cost.

Furthermore, this cost is strongly dependent on the ends expressed by the actors. The question to know if a cost is an environmental cost does not depend on its nature but on the reasons that lead to bear this cost. The example of the moving cost in the case of asbestos removal is a good example. If the move is only driven by the removal of asbestos then the cost of moving should be considered as an environmental cost. If the move is made independently then the cost does not fit into the environmental category. We find here the same result as in Herbohn (2005): although the EMA framework improves the decision process, its implementation is complicated by technical problems (the integration of externalities) and management issues (difficulty to convince all the stakeholders and risks of information manipulation). Our study helps in going from a static report to a proactive management of environmental costs by highlighting their specificities. We supply a sketch of the control levers that may be used to act on the costs and not simply on their recording.

Environmental costs are driven by the uncertainty and the complexity of the cleanup operations, their weak degree of institutionalization and by the end usage of the cleaned building or soil. These drivers, while certainly not specific to environmental costs, have only been little investigated in the literature so far. The study of the costs of environmental and

social responsibility of the firm allows highlighting specific drivers to this domain and so allows us to understand better this phenomenon.

To finish, our case studies confirm some limits previously highlighted in the literature when it comes to implement the EMA framework within organizations. We find two of the failure factors identified by Gray and Bebbington (2001, p. 575): the endless search for precision and the impossibility to obtain all the costs. It seems impossible to list all the constituents of an environmental cost. The results of the study bring us to revise the purpose of an environmental accounting system. It indeed seems to us that such a system should not try to “freeze” environmental costs, as in Xiaomei (2004) or United Nations (2001), but on the contrary try to assess their dynamics.

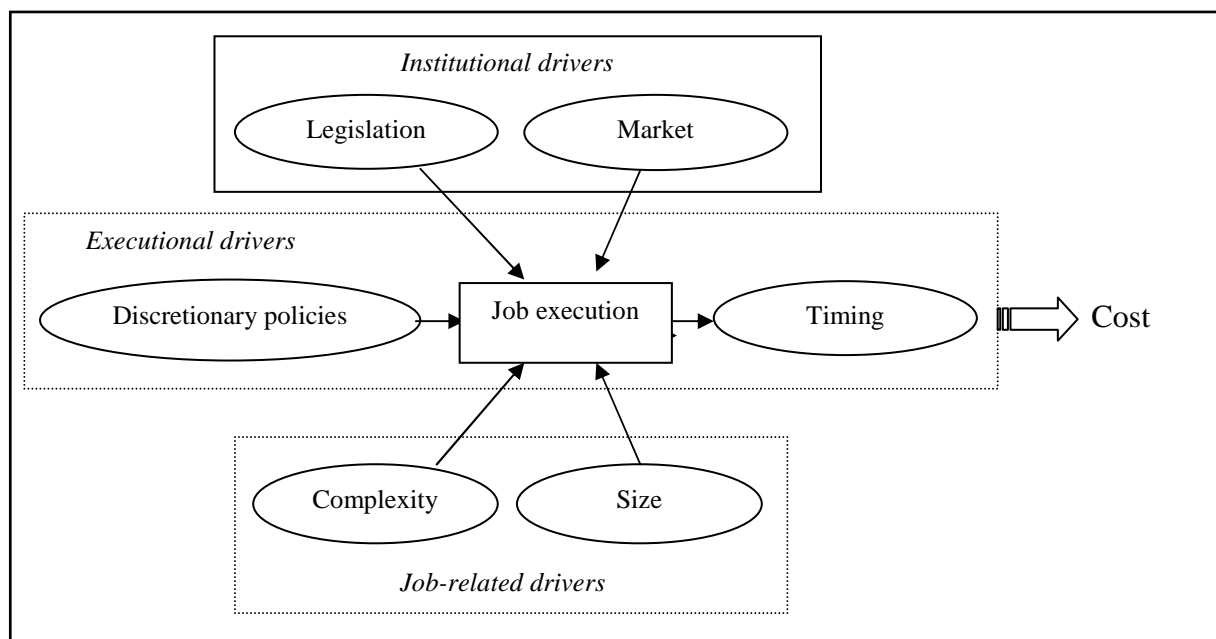
6.3. Environmental cost drivers’ interrelationships

It seems that there is a kind of path-dependency that organizes the relationships between the various environmental cost drivers. This study brings two new lightings. First, it contributes to the development of cost drivers typologies. The transfer of Porter’s (1985) and Riley’s (1987) typologies to environmental issues turned out to be delicate. Some drivers turned out to be non relevant and others, not much developed in the previous typologies, turned out to be very important, as for example the complexity and uncertainty of the cleanup operations.

Second, as Banker and Johnston (2007, p. 552) note: “Some researchers have recognized that many costs and revenues, as well as some of their drivers, involve simultaneous relationships, that is, they are, or should be, simultaneous or jointly determined by managerial decisions and/or external forces. When this is the case, it is important for researchers to develop models that capture the rich, underlying complex set of hypothesized relationships...”

Indeed, links exist between the various cost drivers identified in this paper. Some drivers may reinforce each other’s impact on the total cost of the job whereas others will tend to have a mitigating effect. For example, the legal environment can provoke an increase of the cost, this increase being compensated by the choice of the decision-makers to implement a non expensive technology. On the contrary, the small number of third parties making up the soil remediation market adds up with a very constraining legislation for an increase of the cost of such cleaning operations. Figure 2 below presents a tentative model that captures the relationships between the different environmental cost drivers that were studied in this paper.

Figure 2: Environmental cost drivers and their interrelationships



BIBLIOGRAPHY

- Anderson S.W. (2007), "Managing costs and cost structure throughout the value chain: Research on strategic cost management", in C.S. Chapman et al. (Eds), *Handbook of Management Accounting Research*, Elsevier, p. 481-506.
- Banker R.D., Johnston H.H. (2007), "Cost and profit driver research", in C.S. Chapman et al. (Eds), *Handbook of Management Accounting Research*, Elsevier, p. 531-556.
- Bartolomeo M., Bennett M., Bouma J.J., Heydkamp P., James P., Wolters T. (2000), "Environmental management in Europe: current practice and further potential", *European Accounting Review*, 9(1), p. 31-52.
- Bennett M., James P. (1998), *The Green Bottom Line: Current practice and future trends in environmental management accounting*, Sheffield, Greenleaf Publishing.
- Bjornenak T. (2000), "Understanding cost differences in the public sector – a cost drivers approach", *Management Accounting Research*, 11, p. 193-211.
- Burnett R.D., Hansen D.R. (2007), "Ecoefficiency: Defining a role for environmental cost management", *Accounting, Organizations and Society*, 33(6), p. 551-581.
- Burritt R.L., Hahn T., Schaltegger S. (2002), "Towards a comprehensive framework for Environmental Management Accounting - Links between business actors and environmental management accounting tools", *Australian Accounting Review*, 12(2), p. 39-50.
- Burritt R., Saka C. (2005), "Environmental management accounting applications and eco-efficiency: case studies from Japan". *Journal of Cleaner Production*, 13, p. 1-14.
- Christophe B. (1995), *La comptabilité verte : de la politique environnementale à l'écobilan*, De Boeck Université, Bruxelles.
- Cho C., Patten M. (2007), "The role of environmental disclosures as tools of legitimacy: A research note", *Accounting Organization and Society*, 32, p. 639-647.
- Clarkson P., Li Y., Richardson G.D., Vasvari F.P (2008), "Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis" *Accounting, Organizations and Society*, 33, p. 303-327.
- Cooper R., Kaplan R.S. (1987), "How cost accounting systematically distorts product costs", in W. Bruns & R.S. Kaplan (Eds), *Accounting and Management: Field Study Perspectives*, Boston, Harvard Business School Press.
- Cooper R., Kaplan R.S. (1991), *The Design of Cost Management Systems: Text, Cases and Readings*, Englewood Cliffs, Prentice Hall.
- Cooper R., Kaplan R.S. (1998), *The Design of Cost Management Systems: Text, Cases and Readings*, 2nd edition, Englewood Cliffs, Prentice Hall.

- Cormier D., Magnan M. (2007), "The revisited contribution of environmental reporting to investors' valuation of a firm's earnings: An international perspective", *Ecological Economics*, 6(2), p. 613-626.
- Farley L., Gauthier Y., Leblanc M., Martel L. (1997), *Guide d'introduction à la comptabilité environnementale*, Environnement Canada et Ordre des comptables agréés du Québec.
- Gale R. (2006), "Environmental costs at a Canadian paper mill: A case study of Environmental Management Accounting (EMA)", *Journal of Cleaner Production*, 14, p. 1237-1251.
- Graff R.G., Reiskin E.D., Whitebidwell A.L.K. (1998), *Snapshots of environmental cost accounting. A report to US EPA environmental accounting project*, Boston, Tellus Institute.
- Gray R.H. (2002), "The social accounting project and Accounting Organizations and Society. Privileging engagement, imaginings, new accountings and pragmatism over critique?", *Accounting, Organizations and Society*, 27(7), p. 687-708.
- Gray R.H., Bebbington J. (2001), "An account of sustainability: Failure, success and a reconceptualization", *Critical Perspectives on Accounting*, 12, p. 557-587.
- Gray R.H., Bebbington J., Walters D. (1993), *Accounting for the Environment*, Paul Chapman, London.
- Herbohn K. (2005), "A full cost environmental accounting experiment", *Accounting, Organizations and Society*, 30(6), p. 519-536.
- International Federation of Accountants (2005), *International Guidelines Document on Environmental Management Accounting (EMA)*.
- Jasch C. (2003), "The use of Environmental Management Accounting (EMA) for identifying environmental costs", *Journal of Cleaner Production*, 11, p. 667-676.
- Joshi S., Krishnan R., Lave L. (2001), "Estimating the hidden costs of environmental regulation", *The Accounting Review*, 76(2), p. 171-198.
- Kaplan R.S. (1983), "Measuring manufacturing performance: A new challenge for managerial accounting research", *The Accounting Review*, 58, p. 686-705.
- Kaplan R.S. (1984), "Yesterday's accounting undermines production", *Harvard Business Review*, 84(4), p. 95-101.
- Kitzman A. (2001), "Environmental cost accounting for improved environmental decision making", *Pollution engineering*, December.
- Larrinaga-Gonzalez C., Bebbington J. (2001), "Accounting change or institutional appropriation? A case study of the implementation of environmental accounting", *Critical Perspectives on Accounting*, 12, p. 269-292.
- Lehman G. (1999), "Disclosing new worlds: A role for social and environmental accounting and auditing", *Accounting, Organizations and Society*, 24(3), p. 217-241.
- Miller J.G., Vollmann T.E. (1985), "The hidden factory", *Harvard Business Review*, 63, p. 142-150.
- Porter M.E. (1985), *Competitive advantage*, New York, The Free Press.
- Riley D. (1987), "Competitive cost based investment strategies for industrial companies", in *Manufacturing Issues*, New York, Booz Allen and Hamilton.
- Schaltegger S., Burritt R.L. (2000), *Contemporary environmental accounting - issues, concepts and practice*, Sheffield, Greenleaf Publishing.
- Shank J.K. (1989), "Strategic cost management: New wine or just new bottles?", *Journal of Management Accounting Research*, 1, p. 47-65.
- Shank J.K., Govindarajan V. (1989), *Strategic Cost Analysis: The Evolution From Managerial to Strategic Accounting*, Homewood, Irwin.
- Shank J.K., Govindarajan V. (1993), *Strategic Cost Management: The New Tool For Competitive Advantage*, New York, The Free Press.
- United Nations, Division for Sustainable Development (2001), *Environmental management accounting procedures and principles*, New York.
- Xiaomei L. (2004) "Theory and practice of environmental management accounting: Experience of implementation in China", *International Journal of Technology Management and Sustainable Development*, 3(1), p. 47-57.