

**ECO-CONTROL: THE INFLUENCE OF MANAGEMENT CONTROL SYSTEMS
ON ENVIRONMENTAL AND ECONOMIC PERFORMANCE**

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ABSTRACT

Over the past centuries, industrial development has brought immeasurable wealth and prosperity while also causing unintended ecological degradation. While organizations play a major role in causing and potentially controlling ecological problems, they could also obtain various benefits from practices that have a positive impact on the environment. Environmental management accounting (EMA) helps firms to work to attain those potential benefits and to face their environmental responsibilities. As part of EMA, eco-control is the application of financial and strategic control methods to environmental management. In this study, we examine specifically the integration of environmental concerns in three management control systems within manufacturing firms, namely performance measurement systems (PMS), budgeting and incentives. More specifically, we investigate to what extent those eco-control systems influence environmental and economic performance. Using survey-data from a sample of Canadian manufacturing firms, the results suggest that the three eco-control systems influence positively environmental performance which in turn influences positively economic performance. This study contributes to the management accounting literature by providing insight into the roles and contributions of management accounting in a context of sustainable development.

Keywords: eco-control, environmental management accounting, environmental performance, environmental performance indicators, budget, incentives

1. INTRODUCTION

Over the past centuries, industrial development has brought immeasurable wealth and prosperity while also causing unintended ecological degradation such as global warming, ozone depletion, deforestation and desertification, declining biodiversity, and toxic waste (Shrivastava, 1995). While organizations play a major role in causing and potentially controlling ecological problems, they could also benefit from cost reductions through ecological efficiencies, development of green markets and first-mover advantage, better community relations, and improved image (Hart, 1995; Porter & van der Linde, 1995; Shrivastava, 1995). Environmental management accounting (EMA) helps firms work to attain those potential benefits and to face their environmental responsibilities (Schaltegger & Burritt, 2000). EMA is broadly defined as the identification, collection, analysis and use of financial and non-financial information to support management activities in order to maximize environmental and economic performance and to achieve sustainable business (IFAC, 2005; Bennett & James, 2000; Bartolomeo et al. 2000).

As part of EMA, eco-control is the application of financial and strategic control methods to environmental management (Schaltegger & Burritt, 2000). In recent years, eco-control has attracted growing attention as a means of driving an environmental strategy throughout the firm. Indeed, organizations are increasingly being held responsible for environmental actions, as reflected in the growing number of laws, regulations and penalties in this area. Consequently, organizations are now obliged to measure, control and disclose their environmental performance. Moreover, reliable systems are necessary to supply information

for decision making to ensure the attainment of environmental objectives. Furthermore, the allocation of the organization's limited resources to environmental problem solving requires persuasive evidence supporting the benefits of such actions.

In this study, we examine specifically the integration of environmental concerns in three management control systems within manufacturing firms, namely performance measurement systems (PMS), budgeting and incentives. More specifically, we investigate to what extent those eco-control systems influence environmental and economic performance. This study is motivated by two main purposes: (i) the findings about eco-control in the accounting and environmental management literatures are fragmented and disparate, and (ii) the empirical evidence focusing on the relationship among EMA, environmental and economic performance are scarce.

First, various streams of research have examined environmental accounting in the accounting and environmental management literatures. In particular, an extensive body of literature has examined environmental disclosure and reporting practices (e.g. Gray and Haslam, 1990; Gray, Javad et al., 2001; Burritt, 2002; Deegan & Blomquist, 2005; Lehman, 1999; Neu, Warsame, and Pedwell, 1998; Moneva & Llana, 2000; Lanen, 1999; Marshall & Brown, 2003).¹ While some research has defined the concept of environmental management accounting and has reported current practices (e.g. Bennett & James, 2000; Bartolomeo et al., 2000; Burritt, 2004; IFAC, 2005), other studies have examined the role of accounting / accountants in environmental management (e.g. Gray, 1992; Bebbington, Gray, Thomson,

¹ The interested reader is referred to the work of Berthelot, Cormier and Magnan (2003), Gray, Kouhy et al. (1995) and Mathews (1997) for a complete review of this stream of research.

and Walters, 1994; Wilmshurst & Frost, 2001) and issues related to environmental cost accounting (e.g. Parker, 2000a,b; Letmathe & Doost, 2000; Herbohn, 2005; Antheaume, 2004; Gluch & Baumann, 2004).

However, the notion of eco-control has not been investigated extensively. While some studies have broadly examined the implementation of eco-control systems (e.g. Pondeville & De Rongé, 2005; Epstein, 1996a,b; Epstein & Birchard, 2000), others have examined issues related to specific systems, such as performance measurement (e.g. Perego & Hartmann, 2005; Epstein & Wisner 2005; Bennett & James, 1999b; Eckel, Fisher, and Russel, 1992; Figge, Hahn, Schaltegger, and Wagner, 2002a), budgeting (e.g. Epstein & Wisner, 2005; Parker, 2000a,b; Burritt & Schaltegger, 2001), and incentives (e.g. Epstein & Wisner, 2005; Lothe, Myrtveit, and Trapani, 1999; Gabel & Sinclair-Desgagné, 1993). Overall, most of the research related to eco-control is descriptive or prescriptive, contributing to the further development of tools and often based on a limited number of case studies (Bouma & VanderVeen, 2002; Burritt, 2004). Because this stream of research is hindered by unexplored topics and insufficient empirical evidence, the findings about eco-control remain fragmented and disparate.

Secondly, not only have the issues related to eco-control been overlooked in past research, but there is also a lack of empirical evidence supporting the impact of EMA, including eco-control, on environmental and economic performance. While various studies have documented the positive influence of environmental management systems² on environmental

² Environmental management accounting is one component of environmental management (Eckel et al., 1992; Figge et al.; Epstein, 1994). The purpose of an environmental management system is to develop, implement,

or economic performance (e.g. Klassen & McLaughlin, 1996; Roy, Boiral, and Lagacé, 2001; Melnyk, Sroufe, and Calantone, 2003; Christmann, 2000; Judge & Douglas, 1998; Sharma & Vredenburg, 1998), other studies have examined the relationship between environmental and economic performance (e.g. Russo & Fouts, 1997; Al-Tuwaijri, Christensen, and Hughes, 2004; Wagner, 2005; Wagner & Schaltegger, 2004; McWilliam & Siegel, 2000). However, few empirical studies have tested the influence of EMA on environmental and economic performance (Epstein and Wisner, 2005). Hence, there is a need to further investigate eco-control as one important dimension of EMA and its impact within the organization. Using survey-data from a sample of Canadian manufacturing firms, this study investigates specifically the influence of eco-control systems on environmental and economic performance.

The remainder of this paper is organized as follows: The next section defines the main constructs, describes the theoretical model, and presents our hypotheses. The following section presents the methodology, including a sample definition, data collection and measurement of constructs. We next describe the results of our analyses followed by a discussion and the conclusion of this study.

manage, coordinate and monitor corporate activities to minimize the negative environmental impact of the firm's products throughout their life cycle (Melnyk et al., 2003; Klassen & McLaughlin, 1996).

2. THEORETICAL FRAMEWORK

2.1 Definition of constructs

Eco-control systems

Eco-control refers to the integration of environmental concerns within management control systems. Following the definition of management control systems from Simons (1987, 1990), eco-control has been defined as the formalized procedures and systems that use financial and ecological information to maintain or alter patterns in environmental activity. We next describe specifically three important components of eco-control: PMS, budgeting and incentives. Those components have been chosen as they represent control systems for which a rich body of literature has been developed in the management accounting literature (Shields, 1997; Ittner and Larcker, 2001).

Performance measurement systems (PMS) are defined as tools used to quantify the actions of an organization (Neely, Gregory, and Platts, 1995). In the context of eco-control, PMS refer to the collection and disclosure of information regarding environmental performance. Two dimensions of PMS are investigated in this study, namely diversity of measurement and use (Perego & Hartmann, 2005; Henri, 2006a). Measurement diversity is a broad concept that relates to various dimensions: economic versus ecological measures, input versus output measures, process versus results measures, internal versus external measures, operational versus managerial measures, etc. (e.g. Bennett & James, 1999a; Schaltegger & Burritt, 2000; Veleva & Ellenbecker, 2000; Scott & Tiesen, 1999; Ittner, Larcker, and Randall, 2003). In

this study, measurement diversity refers specifically to the attention devoted by the firm to the measurement of various types of environmental performance indicators. It emphasizes the multiplicity and variety of environmental performance indicators that are available within the organization (e.g. inputs of energy, outputs of solid waste, conformity with requirements or expectations, financial impact).

While diversity of measurement refers to the 'content' of PMS, the use refers to the extent to which performance indicators are used by managers for environmental management. Different uses of performance indicators have been examined in the management accounting literature such as monitoring goals achievement, focusing organizational attention, supporting decision-making and external reporting (e.g. Atkinson et al, 1997; Bisbe & Otley, 2004; Henri, 2006b; Ittner et al, 2003; Simons, 2000). However, less attention has been devoted to the various types of use of environmental performance indicators in the environmental management literature (notable exceptions include Bennett & James (1998) and Briassoulis (2001)). From the overlap between the management accounting and environment literature, four main uses are reflected and examined in this study: (i) to monitor compliance with environmental policies and regulation, (ii) to motivate continuous improvement, (iii) to provide data for internal decision-making, and (iv) to provide data for external reporting.

Budgeting is an important control mechanism in nearly all organizations (Hansen & Van der Stede, 2004; Hansen, Otley, and Van der Stede, 2003; Abernethy & Brownell, 1999; Ekholm & Wallin, 2000). Since it provides the information necessary to direct or guide individual and

group actions, it is one vehicle for promoting goal congruence between the individual and the organization (Flamholtz, Das, and Tsui, 1985; Flamholtz, 1983). Budgets are used by management as a means of coordinating and communicating strategic priorities (Abernethy & Brownell, 1999). In the context of eco-control, environmental budgeting, which is one aspect of global budgeting, specifically involves the setting of detailed goals for environmental expenses, incomes from material scrap or recycled wastes, and environmental investments.

Incentives are used to facilitate managers' commitment to strategic priorities. They are a source of motivation toward organizational goals and they serve to reinforce or modify particular behaviour (Flamholtz et al., 1985). In the context of eco-control, the integration of environmental criteria in the incentive system is used to direct managerial effort towards environmental activities (Gabel & Sinclair-Desgagné, 1993). Environmental goals can be achieved with an incentive system that encourages managers to focus on both profit-related activities and activities related to environmental performance (Lothe et al., 1999).

Environmental performance

Although judgments are frequently made about which companies are 'greener', there is no clear or agreed upon definition of what constitutes environmental performance (Lober, 1996). There is still a significant lack of agreement concerning the definition and operationalization of the concept. In the accounting literature, environmental performance has been mainly examined in terms of the *environmental impacts* generated in the conduct of business, such as hazardous wastes recycled (Al-Tuwaijri et al., 2004), toxic releases (Patten,

2002), pollution-level in discharged water (Cormier and Magnan, 1997), non-compliance with environmental statutes (Mobus, 2005), or environmental ratings of firms developed by external groups (i.e., Council on Economics Priorities' (CEP) company rating chart, Dow Jones Sustainability Index, etc.).

However, the use of environmental impacts as a proxy for environmental performance may restrict the scope of this multidimensional concept to only one aspect (Ilinitich, Soderstrom, and Thomas, 1998). Indeed, the concept of organizational performance is not limited to only a financial aspect but also integrates other aspects (i.e., customer satisfaction, productivity, quality, innovation); Similarly, the concept of environmental performance covers various aspects. Building on the work of organizational theorists that have examined the concept of effectiveness since the 1950s (Henri, 2004), we use different effectiveness models to define environmental performance, namely the goal model, the system model, the strategic-constituencies model and the competing-values model. Based on those models, environmental performance is divided into four main dimensions, namely results versus process, and internal versus external (Ilinitich et al. 1998). These dimensions are discussed next specifically.

First, the results dimension is measured in terms of accomplishment of outcomes (Etzioni 1960). Reflecting the goal model, the focus is on the ends: achievement of financial and environmental outcomes. Hence, the environmental impacts used in past accounting research refer to this dimension, as well as the financial consequences of environmental practices. Although various authors have underlined the crucial importance of financial impact in the

environmental management literature (e.g., Bennett & James, 2000; Porter & van der Linde, 1995), that impact has not been addressed explicitly as an aspect of environmental performance.

Moreover, the process dimension of environmental performance refers to the system model. While not neglecting the importance of the ends, the system model emphasizes the means needed for the achievement of specific ends (Yuchtman and Seashore, 1967). Thus, reflecting a group of studies in the environmental management literature (e.g., Sharma & Vredenburg, 1998; Melnyk et al., 2003), environmental performance also refers to the process and product improvements resulting from the integration of environmental consideration in the operational decisions of the firm. Furthermore, following the strategic-constituencies model, the process dimension also considers the various powerful interest groups that gravitate around the organization (Connolly et al., 1980). Consequently, reflecting the importance devoted to stakeholder relations within the environmental management literature, our definition of environmental performance also refers to the capacity of the organization to establish harmonious relationships among various stakeholders concerned with environmental issues.

The internal and external dimensions are part of the competing-values model (Quinn and Rohrbaugh, 1983; Quinn, 1988). This model views the assessment of performance as an exercise grounded in values whereby performance is described along two sets of competing values, including internal versus external focus. In a context of environmental performance, the internal values invoke ‘managerialism’ {Gray, 2000 #123}. The latter refers to a

business-oriented view of environmental performance whereby the economic consequences (financial and operational) of environmental actions are emphasized in the assessment of environmental performance. The external values refer to a sustainability-oriented view of environmental performance whereby environment protection and enhancement are given a greater place (Gray and Bebbington, 2000).

To integrate those various dimensions of environmental performance, we have adapted the integrative matrix developed by Ilinitich et al. (1998) and Lober (1996). The environmental performance matrix contains two axes: (a) the vertical axis separates the dimensions of process and results, and (b) the horizontal axis reflects the internal and external dimensions. The junction of those two axes provides a framework for organizing the various views of environmental performance into four aspects. We define specifically those aspects as follows: (i) environmental impacts and corporate image (external / results), (ii) stakeholder relations (external / process), (iii) financial impact (internal / results), (iv) process and product improvements (internal / process). Each of these four aspects is necessary but not sufficient to environmental performance. Only collectively can they help a firm to be effective. This is why those four aspects are integrated into our definition as well as the operationalization of environmental performance. More specifically:

1. Environmental impacts and corporate image refer to the overall reputation of the company and the degree to which organizations meet or exceed standards required by laws and regulations related to emissions and discharges.

2. Stakeholder relations refer to the interaction between the organization and its various external constituencies, including its shareholders, the local community, government, customers, suppliers, and industry.
3. Financial impact refers to the monetary consequences associated with environmental practices such as reduction in material costs, reduction in process/production costs and reduction in costs of regulatory compliance.
4. Process and product improvements refer to the integration of environmental issues in the operations resulting in competitive advantage for the organization such as improved quality, increased productivity and improved innovation.

2.2 Overview of the theoretical model

Figure 1 presents a summary of the theoretical model that reflects the relationships among three eco-control systems (PMS, budgeting and incentives), environmental performance, and economic performance. Each of the eco-control systems is expected to have a positive and direct influence on environmental performance. Furthermore, environmental performance is expected to contribute positively to economic performance. Thus, each of the eco-control systems is expected to have an indirect effect on economic performance through environmental performance. These relationships are discussed more specifically below. Finally, considering the potential influence of other factors on environmental performance and/or economic performance documented in past research, such as environmental strategy, stakeholder pressures, firm size and ownership (Capon, Farley, and Hoenig, 1990; Sharma & Vredenburg, 1998; Judge & Douglas, 1998; Buysse & Verbeke, 2003; Wagner &

Schaltegger, 2004; Henriques & Sadosky, 1999; Marshall & Brown, 2003), the latter are used as control variables.

-- Insert figure 1 --

2.3 Relationship between PMS and environmental performance

While little evidence has been provided in past research to support the link between the diversity of measurement of PMS and environmental performance, the management accounting literature encompasses various studies supporting a positive relationship between an increased reliance on a diverse set of performance measures and economic performance (e.g. Baines & Langfield-Smith, 2003; Ittner et al., 2003; Scott & Tiesen, 1999; Said, Elnaby, and Wier, 2003; Hoque & James, 2000; Davila, 2000; Luft & Shields, 2003). Those studies are used as theoretical support to advocate a positive association between PMS and environmental performance.

More specifically, PMS which contain more diversity in the measurement of environmental issues (i.e. multiplicity and variety) reflect a more complete picture of the firm's environmental activities. Appropriate accounting information supports effective resource management and contributes to environmental performance (Baines & Langfield-Smith, 2003). By clarifying and translating vision and strategy, PMS with greater diversity will direct managers to critical areas of environmental concerns and will communicate the associations between employees' actions and environmental goals (Kaplan & Norton, 1996; Nanni, Dixon, and Vollmann, 1992). Moreover, they will improve the allocation of resources

and the establishment of priorities based on such environmental goals (Kaplan & Norton, 1996).

PMS with greater diversity of measurement may reflect characteristics of integrativeness (Chenhall, 2005). They may contain a set of indicators providing an understanding of cause-effect linkages among environmental operations, strategy and goals, as well as among environmental issues and various components of the value chain. This comprehension of causality by managers may contribute to a better alignment of environmental goals and internal processes, and stimulate organizational learning, which ultimately may lead to improvement in environmental performance. Specifically, PMS with greater diversity of measurement can assist alignment by explicitly identifying, mapping, measuring and communicating throughout the organization the effects of linkages among environmental actions and environmental performance (Chenhall, 2005). Based on the previous arguments, we hypothesize the following:

H1a: *Measurement diversity within PMS is associated with increased environmental performance.*

On the other hand, the use of PMS for environmental purposes also supports effective resource management and contributes to environmental performance. First, when used to *monitor compliance with policies and regulations*, PMS support the attainment of pre-established environmental goals and closely monitor deviations from regulations (Simons, 1990,1995). Indeed, this reflects a feedback system relying on a cybernetic logic whereby goals are set in advance, output is measured, goals and output are compared, feedback is

provided, and corrections are made if necessary (Hofstede, 1978). By providing feedback regarding the differences between goals and outputs, this use leads to single-loop learning (Argyris & Schön, 1978).

Moreover, this monitoring use of PMS restricts risk taking and provides boundaries for excessive environmental innovation (Miller & Friesen, 1982). It also represents one instrument of communication between managers and subordinates. As Kenis (1979) observed, communication of goals downward in an organization informs subordinates about the expectations of upper-management. Conversely, through upward-flowing reports comparing goals with actual performance, upper-management learns about the accomplishments and problems of lower management. Lastly, at the individual level, goal and feedback enhance environmental performance by clarifying expectations, reducing ambiguity associated with tasks to achieve environmental strategies, and providing a coherent reflection of environmental priorities (Chenhall, 2005).

Second, managers constantly oversee strategic and operational issues and require information to support their analytical processes concerning issues in which they are taking the lead, or to explore ideas proposed by others (Langley, 1990). Based on decision theory, the use of information and decision making are traditionally linked (Feldman & March, 1981). PMS, as a source of information, *provide data for internal decision-making*. By revealing cause-and-effect relationships among environmental operations, strategy and goals (Atkinson, Waterhouse, and Wells, 1997; Chenhall, 2005), PMS are used as a facilitator during the decision-making process and may contribute to environmental performance. Managers need a considerable amount of information from the PMS to support decisions made related to cost

reduction, process and production efficiency, regulatory compliance, and product improvement (Epstein, 1996b; Burritt, 2004; Eckel et al., 1992).

Third, PMS *motivate continuous improvement* by focusing organizational attention. They send cues related to environmental issues, promote discussion, debate, and exchanges of information (Simons, 1990). In providing an agenda and a forum for regular face-to-face debate and dialogue, PMS support the development of environmental initiatives leading to cost reductions, process innovations and product improvements. Indeed, they have the power to represent a positive trigger that fosters creative and inspirational forces (Simons, 1995). According to Dent (1990), curiosity and experimentation can be fostered by control systems, such as PMS. By motivating continuous improvement, PMS contribute to the development of complex rules and associations regarding new actions, and the development of an understanding of causation, which is associated with double-loop learning (Argyris & Schön, 1978).

Fourth, PMS can also contribute to environmental performance when used to *provide data for external reporting*. Indeed, environmental reporting represents a means for the organization to respond to the various pressures of stakeholders (e.g. investors, customers, shareholders, etc.) by disclosing financial and non-financial impacts of environmental matters. Those practices contribute to the creation of a good corporate image, influence reputation and gain marketing benefits by influencing the public's perception towards the operations of the organization (Dixon, Mousa, and Woodhead, 2005). Environmental disclosures may be used to seek or maintain social legitimacy (Patten, 2005). More specifically, organizations must demonstrate that they are operating within the norms and

values of society in order to reduce the likelihood of costly public policy actions against the organization. These arguments lead to the following hypothesis:

H1b: *The use of PMS to monitor compliance, to motivate continuous improvement, to support decision-making and to support external reporting is associated with increased environmental performance.*

2.4 Relationship between budgeting and environmental performance

While past research does not reveal much evidence supporting the link between budgeting and environmental performance, a number of studies have found a positive relationship between budgeting and economic performance (e.g. Brownell, 1982; Brownell & Merchant, 1990; Emsley, 2000; Merchant, 1981; Abernethy & Brownell, 1999; Shields & Young, 1993; Luft & Shields, 2003). Once again, those studies are used as theoretical support to advocate a positive association between the integration of detailed environmental expenses, incomes and investments within the budgeting system and environmental performance.

More specifically, budgeting can be used for multiple purposes within organizations. For instance, budgeting is used for operational and strategic planning, control and performance evaluation, communication of goals, empowerment, motivation, resources allocation, coordination, cost control and management, strategy formation and implementation, etc. (e.g. Hansen & Van der Stede, 2004; Ekholm & Wallin, 2000; Hope & Fraser, 1997; Shields & Shields, 1998; Collins, Holtzmann, and Mendoza, 1997). Those different uses contribute to resource management and influence the probability that people will behave in ways that lead

to the attainment of environmental objectives (Merchant, 1982; Flamholtz, 1983). By guiding individual and group actions, the budget becomes one vehicle in promoting environmental goal congruence between individuals and the organization (Flamholtz et al., 1985; Cyert & March, 1963). Furthermore, the budget can be considered to be a database which facilitates learning related to environmental matters (Abernethy & Brownell, 1999). Indeed, a budget involves communication between subordinates and superiors during the budget setting process and ongoing dialogue as to why variances occur and what actions should be taken (Abernethy & Brownell, 1999; Kenis, 1979). Hence, formally stated:

H2: *The integration of detailed environmental expenses, incomes and investments within the budgeting system is associated with increased environmental performance.*

2.5 Relationship between incentives and environmental performance

As with PMS and budgeting, little evidence has been provided by past research to support the link between incentives and environmental performance. However, the accounting literature presents considerable empirical evidence supporting a positive relationship between incentives and economic performance (e.g. Bonner et al., 2000; Shields, 1997; Luft & Shields, 2003; Kren, 1997; Enis, 1993). Those studies are used as theoretical support to advocate a positive association between incentives and environmental performance.

More specifically, the integration of environmental matters in employee evaluation varies depending on the extent to which environmental criteria are important in the reward systems and the extent to which they are weighted on par with economic performance indicators

(Sharma, 2000). For organizations that want to improve environmental performance, the development of incentives is important (Epstein, 1996a). They influence behaviours toward desired organizational directions (Flamholtz et al., 1985). Incentives motivate people to align their behaviour with the environmental goals of the organization and facilitate commitment to strategic priorities (Epstein, 1996a). They motivate people to exert additional effort, which in turn should improve environmental performance (Bonner, Hastie, Sprinkle, and Young, 2000).

Incentives send a clear message from top-management that environmental performance is important to the firm (Epstein, 1996a). Environmental goals can be achieved with an incentive system that forces managers to focus on both profit-related activities and activities related to environmental performance (Lothe et al., 1999; Gabel & Sinclair-Desgagné, 1993). If performance is rewarded based only on profit or revenue contributions, employees quickly recognize that trade-offs on the environment are acceptable and thus, environmental performance will be affected negatively (Epstein, 1996a). Hence, formally stated:

H3: *The integration of environmental criteria in the incentive system is associated with increased environmental performance.*

2.6 Relationship between environmental performance and economic performance

A number of empirical studies investigating the link between environmental performance and economic performance have returned different verdicts: positive, negative or neutral impact (e.g., Al-Tuwaijri et al., 2004; Russo & Fouts, 1997; McWilliam & Siegel, 2000; Hart,

1995). These inconclusive results may primarily be due to methodological shortcomings and the failure to conceptually trace how environmental performance influences economic performance (Wood & Jones, 1995; Russo & Fouts, 1997). Following the work of Porter & van der Linde (1995) who recognize the positive influence of environmental improvement on competitiveness, we present various conceptual arguments suggesting a positive association between environmental and economic performance.

Despite initial investments that increase costs in the short run, operating costs can be reduced by exploiting ecological efficiencies, such as waste reduction, energy conservation, materials reutilization, and life-cycle costs perspective (Porter & Van der Linde, 1995). Furthermore, superior environmental performance provides a basis for creating a competitive advantage and the opportunity to increase revenues by fulfilling the needs of “green” consumers (Hart, 1995). Following the resource-based view of the firm, organizational performance would be enhanced by (i) physical assets and environmental technology that outperform equivalent assets within competitors, (ii) development of unique organizational capabilities related to environmental management, and (iii) intangible resources such as reputation for leadership in environmental affairs and the ability to influence public policies in ways that would give a competitive advantage (Russo & Fouts 1997).

The positive association between environmental and economic performance can also be explained by the potential for reducing long-term risks associated with resource depletion, fluctuations in energy costs, product liabilities, as well as pollution and waste management (Shrivastava, 1995). Furthermore, by cutting emissions well below the required level, firms

can reduce compliance and liability costs and get ahead of the regulatory curve (Shrivastava, 1995). Lastly, it is worth mentioning that superior environmental performance provides the opportunity to improve public relations and corporate image, as well as gain social legitimacy (Dixon et al., 2005; Patten, 2005).

Three eco-control systems, namely PMS, budgeting and incentives have been linked to environmental performance (hypotheses 1a, 1b, 2 and 3). Increases in environmental performance are expected to increase economic performance. Thus, eco-control systems are expected to enhance economic performance through environmental performance. Therefore, the following hypothesis is proposed:

H4: *Three Eco-control systems (PMS, budget and incentives) have an indirect effect on economic performance through their contribution to environmental performance.*

3. RESEARCH METHOD

3.1 Research Design

We collected data from a survey administered to a random sample of 1500 Canadian manufacturing firms from Scott's Manufacturing 2004 database. In this study, 'firm' is a fully autonomous entity or a subunit of a larger firm. In all cases, they appeared as separate entities in the database. We selected organizations with 100 employees or more, and reporting sales of over \$20 million. These criteria are intended to ensure that organizations are large enough for organizational variables to apply (Miller, 1987) and that management

control systems are sufficiently developed (Bouwens & Abernethy, 2000). The final sample comprised 1447 organizations (considering wrong addresses, organizations that moved, etc).

The questionnaire was first validated using a pre-test administered to various academics and managers. This pre-test confirmed the understanding of each of the measurement instruments. We then sent the questionnaire to the CEO or another member of the top-management team (COO or senior vice-president) of each firm along with a letter explaining the purpose of the study and a self-addressed stamped envelope was included with the questionnaire. Three weeks after the initial mailing, 500 organizations randomly selected from among the non-respondents received a reminder by telephone. All the other organizations that did not respond to the questionnaire following the initial mailing and that were not selected for the telephone follow-up received a replacement questionnaire.

We received a total of 303 usable questionnaires, for a response rate of 20.9%³. On average, firm size was 710 employees and the respondents had on average 13.7 years of experience working for their organization. Appendix 1 presents a complete profile of the respondents. We performed an analysis of the non-response bias to confirm the validity of the data. Initially, the comparison between respondents and non-respondents with respect to size, industry and geographical region did not reveal any significant differences. Moreover, the comparison between the first and last 10% of respondents (the latter being used as a proxy

³ Current literature suggests that a sample size varying between 100 and 200 cases is adequate for small-to-medium structural-equation models, or between 5 to 10 subjects per estimated parameters (Bentler & Chou, 1987; Anderson & Gerbing, 1988). In the current study, the sample size is adequate to test the proposed model (n=303) but the ratio of subject per parameter is slightly below the threshold (4.7). Furthermore, based on the guidelines of MacCallum, Browne, and Sugawara (1996), this study has adequate power (i.e. 0.99).

for the non-respondents) did not reveal any significant differences in the responses obtained for the main constructs of the study (i.e. eco-control systems, environmental performance and economic performance). Hence, it appears that non-response bias is not a major concern in this sample.

3.2 Measurement of Constructs

Appendix 2 presents the instruments used to measure the main constructs. Descriptive statistics of the main constructs and correlation matrix are presented in Table 1. Two instruments were used to collect data on the dimensions of PMS. The diversity of measurement was assessed using an instrument developed based on the ISO 14031 standard. This standard, a sub-category of the ISO 14001, concerns the measurement of environmental performance. The ISO 14001 represents an international and well-recognized standard which is accepted and implemented around the world (Peglau, 2004). The instrument included 13 items, each on a seven-point Likert-type scale. The respondents were asked to rate the importance devoted to measurement of those items. The items cover a broad scope of environmental performance indicators from the three categories described in the ISO 14031 guidelines (i.e. operational, managerial and environmental condition indicators). A higher score indicates more importance devoted to the measurement of the specific item. The use of PMS was measured using an instrument developed by Bennett & James (1998) containing four items ranging on a seven-point Likert-type scale. The respondents were asked to indicate to what extent the organization uses environmental performance indicators to (i) monitor internal compliance with environmental policies and regulations, (ii) provide data for internal

decision-making, (iii) motivate continuous improvement, and (iv) provide data for external reporting. A higher score indicates a greater extent of use of PMS.

We developed a three-item instrument to measure the integration of environmental issues in the budget. The instrument contains three questions asking the respondent to rate the extent to which (i) environmental expenses, (ii) environmental investment, and (iii) incomes from material scrap or recycled waste are detailed in the budget of the organization, each on a seven-point Likert-type scale. A higher score indicates a more detailed integration of environmental matters in the budgeting of the firm. The integration of environmental criteria in the incentive system was measured using an instrument developed by Sharma (2000) containing three items ranging on a seven-point Likert-type scale. A higher mean score indicates more integration of environmental criteria in the incentive system.

Environmental and economic performance are measured using a subjective instrument. As several authors argue, in terms of consistently providing valid and reliable performance assessment, neither objective nor subjective measures are superior (e.g., Venkatraman & Ramanujam, 1987; Dess & Robinson, 1984). Environmental performance is adapted from the instrument developed by Sharma & Vredenburg (1998). The questionnaire contains fifteen items ranging on a seven-point Likert-type scale and covers the two axes of the environmental performance matrix discussed previously, namely (i) process (nine items) and results (six items), and (ii) internal (eleven items) and external (four items). The respondents were asked to indicate the extent to which environmental practices have led to fifteen types of benefits (e.g. reduction in material costs, increased productivity, better relationships with

stakeholders, overall company reputation). A higher score indicates better environmental performance. In order to establish the validity of the answers provided by the respondents, the mean score of the items was compared with objective data obtained from a public database. The results show significant correlations between those two sets of data and thus, support the validity of the construct.⁴

Economic performance is measured with an instrument using three indicators: (i) return on investment (ROI); (ii) operating profits, and (iii) cash flow from operations. The respondents were asked to indicate the performance of their organization for the past twelve months compared to their leading competitors. An average score is computed whereby a higher mean score indicates better financial performance. Lastly, we measured the control variables as follows. Environmental strategy is measured using twelve items from the instrument of Aragon-Correa (1998). An average score is computed whereby a higher mean score indicates a more proactive environmental strategy. The stakeholder pressures are measured using the instrument of Buysse & Verbeke (2003) containing sixteen items. An average score is computed whereby a higher mean score indicates more pressure from stakeholders. Size is measured using the natural log of the number of employees, while ownership is measured using a dichotomous variable (0= privately owned; 1= publicly traded).

⁴ Data were collected from the National Pollutant Release Inventory (NPRI) provided by the federal government of Canada. This database contains information on more than 300 pollutants released and transferred from individual facilities across Canada (air, water, land and injected underground and transferred off-site to disposal, treatment, sewage, energy recovery and recycling). Of the 303 firms in our sample, we have been able to identify 138 of them in the database. Negative and significant correlations have been established between the mean score of environmental performance as provided by the respondents of the survey and (i) the natural log of total pollutants released from the firm (-0.20 $p < 0.05$), (ii) the natural log of the firm's total pollutants released minus the natural log of the average of its specific industry (-0.21 $p < 0.05$), and (iii) the natural log of the firm's total pollutants released divided by the natural log of the firm's sales (-0.18 $p < 0.05$). Hence, the self-rated environmental performance is negatively correlated with the level of pollutants released. In other words, the firms that reported having a good environmental performance are those that have less pollutants released.

To establish the reliability of each construct, we examined the Cronbach Alpha and composite reliability. The constructs must exceed the recommended cut-off point of 0.70 to reflect acceptable level (Nunnally, 1967; Fornell & Larcker, 1981). Moreover, to verify convergent validity, the variance extracted has been analyzed and we have performed confirmatory factor analyses (CFA) for each construct. The variance extracted must exceed the recommended cut-off point of 0.50 to reflect acceptable validity (Hair et al., 1998). Three main elements were examined for the CFA, namely the significance of the standardized factor loading and the R^2 for each item, and the overall acceptability of the measurement model using chi-square statistics and three fit indices. Those indices, namely NNFI (non-normed fit index), CFI (comparative-fit index), and RMSEA (root mean square error of approximation) reflect two complementary types of indices (absolute fit and incremental fit measures) and they are among the most frequently reported.⁵ Lastly, discriminant validity has been assessed by comparing the variance extracted from each individual with the squared correlation between latent constructs (Fornell & Larcker, 1981). To support discriminant validity, the variance extracted for each construct must exceed the squared correlations.

Appendix 2 presents the statistics of measurement analysis for the initial and respecified models. Respecifications were necessary for the following constructs: (i) PMS – diversity of measurement (two items were deleted because of inadequate R^2 and variance extracted < 0.50); (ii) budgeting (one item was deleted because of inadequate R^2); and (iii) environmental performance (two items were deleted because of inadequate R^2 and variance extracted <

⁵ The threshold values recommended are (i) NNFI > 0.90 (Tabachnick & Fidell, 2001), (ii) CFI > 0.95 (Hu & Bentler, 1995), and (iii) RMSEA < 0.10 (Browne & Cudeck, 1993).

0.50). After those respecifications, all constructs exceed the recommended cut-off point for the Cronbach Alpha, composite reliability and variance extracted, exhibit acceptable model fit, reflect adequate R^2 , and all factor loadings are statistically significant ($p < 0.01$). The comparison between the variances extracted and the squared correlations supports the discriminant validity of the constructs except for PMS design and PMS use which appear to be correlated. Consequently, in subsequent analysis of structural models, the parameter related to the correlation between those two constructs will be released.

-- Insert table 1 --

3.3 Data analysis

Structural equation modeling (SEM) is used to specifically test our hypotheses. SEM consists of a set of linear equations that simultaneously test two or more relationships among directly observable and/or unmeasured latent variables (Bollen, 1989; Bollen & Long, 1993). We analyzed data collected from the survey with LISREL 8.72 and used a covariance matrix as an input matrix.⁶ To check the overall goodness of fit of a model in the presence of multivariate non-normal data, maximum likelihood estimates, which are robust to such violations, and multiple indices, are suggested (Bentler & Chou, 1987). Furthermore, composite indices and a partial disaggregation approach were used to represent latent constructs of this study, namely eco-control systems, environmental and economic performance (Bagozzi & Heatherton, 1994).⁷ As suggested by Landis et al. (2000), three

⁶ The input matrices are available from the author upon request.

⁷ Composite indices represent aggregates of items which are used as manifest indicators of a latent construct. As suggested by Hall, Snell, and Foust (1999), items parcelling presents several advantages. First, it tends to provide results that are more reliable and normally distributed, and to have values that are more continuously

indicators were used per latent construct. Also, among various methods proposed to form composite indices, the single-factor method has been chosen⁸.

4. RESULTS AND DISCUSSION

4.1 Results of the structural equation model

Table 2 presents the results in terms of path coefficients, *Z* statistics, number of iterations, proportion of variance (R^2), and goodness-of-fit indices. The latter respect the recommended threshold mentioned previously, except for the RMSEA which is slightly above the threshold. This globally indicates a good fit of the data to the global model. No respecification was made to the theoretical model and no starting values were used. The results show positive and significant path coefficients between environmental performance and (i) the use of PMS (0.207 $p < .05$), (ii) budgeting (0.114 $p < .001$), and (iii) incentives (0.173 $p < .001$). However, we do not observe a significant relationship between the diversity of measurement within PMS and environmental performance. These results are obtained after controlling for environmental strategy, stakeholder pressures, size and ownership. The results also reflect a positive and significant relationship between environmental performance and

distributed. Furthermore, by reducing sources of contamination, composite indices contribute to the overall fit of the model. Finally, these indices are useful to reduce the number of parameters in the model and thus contribute to model identification. Using a partial disaggregation approach, each dimension is represented as a separate latent variable indicated by composites of subscales. Several composites are formed for each dimension in which each composite is a mean of items (Bagozzi & Heatherton, 1994).

⁸ In this method, all items are subjected to a factor analysis in which a single-factor solution is specified. The items are then paired based on their resulting factor loadings: the item having the highest factor loading is paired with the item having the lowest loading. This process is repeated until all items have been assigned to composites. There are three main reasons that have motivated this choice. First, while there is no consistent agreement on the best approach, the single-factor method belongs to a group of methods which clearly provides superior results (Landis et al., 2000). Moreover, the single-factor method is one of the most frequently reported methods. Finally, this method reduces an original scale to a reduced number of indicators that are empirically balanced measures of the construct (Mathieu & Farr, 1991).

economic performance (0.129 $p < .05$). The proportion of variance in environmental performance that is accounted for by the eco-control systems is 31.5% while the proportion of variance in economic performance that is accounted for by the environmental performance is 1.6%. The latter coefficient is quite low but is explained by the myriad of factors that have an impact on the economic performance other than environment.

- Insert table 2 -

4.2 Hypotheses tests and discussion

First, the results bring partial support to the hypotheses related to PMS. Specifically, the results provide support to hypothesis 1b by indicating that the use of PMS is significantly associated with environmental performance after controlling for environmental strategy, stakeholder pressures, size and ownership (0.207; $p < .05$). On the other hand, no significant association was observed between diversity of measurement within PMS and environmental performance. Thus, no support is provided for hypothesis 1a. Those effects suggest that despite the importance of the ‘content’ of PMS to provide appropriate information, what may specifically contribute to environmental performance is the way that indicators are used by managers. For instance, a firm may have a large set of environmental performance indicators but use them occasionally only to monitor compliance or only for external reporting to gain social legitimacy. Conversely, a firm may have fewer indicators reflecting critical issues and use them extensively not only for monitoring or reporting but also as a management support tool. Specifically, fewer indicators may be used extensively to support decision-making and

motivate continuous improvements and thus, contributing to cost reduction, process innovation and product improvement.

Furthermore, it is possible that only a few indicators or a specific type of indicator may be adequate and necessary to direct organizational attention toward environmental matters and send signals reflecting the importance of the environment for the organization. A large set of environmental performance indicators may not provide supplementary advantages and in the worst cases, could even lead to information overload (O'Reilly, 1980; Schick, Gordon, and Haka, 1990; Iselin, 1988). For instance, proponents of environmental aggregate indices argue that indices reduce the clutter of too much information, help communicate information succinctly and make patterns in the data easier to see, and formalise the aggregation process that is often done implicitly (e.g. Jollands, Lermitt, and Patterson, 2004; Krajnc & Glavic, 2005; Siracusa, Rosa, and Sterlini, 2004).

Second, the results support hypotheses 2 and 3 as indicated by the positive and significant coefficient between (i) budgeting and environmental performance (.114; $p < .01$), and (ii) incentives and environmental performance (.173; $p < .01$), after controlling for environmental strategy, stakeholder pressures, size and ownership. Those effects are likely due to the potential of budget and incentives to guide and influence individual and group actions toward the attainment of environmental objectives. By integrating environmental matters into the budgeting process and incentive systems, goal congruence is promoted, organizational learning is fostered, and people are motivated to exert additional effort.

Third, hypothesis 4 predicts an indirect relationship between eco-control systems and economic performance through their contribution to environmental performance. Hypotheses 1b, 2 and 3 were supported, which suggest the influence of eco-control systems on environmental performance. Furthermore, the results of the structural equation model show a positive and significant relationship between environmental performance and economic performance after controlling for size and ownership (.129; $p < .05$). This suggests that firms benefit from cost reductions through ecological efficiencies, development of green markets and first-mover advantage, better community relations, and improved image (Hart, 1995; Porter & van der Linde, 1995; Shrivastava, 1995). Hence, support is provided for hypothesis 4. Thus, eco-control systems seem to influence environmental performance, which in turn contributes to economic performance.

4.3 Sensitivity analyses

In order to validate the robustness of the results, various complementary analyses have been conducted. First, our conceptual model is based on an indirect relationship between eco-control systems and economic performance through environmental performance. In order to examine the potential direct effect of eco-control systems on economic performance, the structural model has been run adding direct structural paths from PMS, budget and incentives to economic performance. The results do not show direct relationships between eco-control systems and economic performance. Moreover, the indirect relationship between eco-control systems and economic performance, through environmental performance, continued to be supported by the results.

Second, to examine the potential influence of industry on the results of our model, two analyses were conducted. The structural model was first run with the environmental and economic performance variables operationalized as follows: the three composite indices of those two variables are adjusted for industry by subtracting the dominant two-digit industry average from their respective firm counterparts. The results remain qualitatively unchanged. Then, based on the National Pollutant Release Inventory (NPRI) provided by the federal government of Canada (see footnote 4), the sample was divided into two groups: (i) firms pertaining to a low-polluting industry (n=203), and (ii) firms pertaining to a high-polluting industry (n=100). The structural model was run on each group to validate the robustness of the global model. Table 3 presents the results of this analysis.

-- Insert table 3 --

The results for the two groups remain qualitatively unchanged compared to the global model, except for two structural paths. For the firms in the low-polluting industries, the relationship between environmental performance and economic performance is not significant. This may suggest that the relative importance of the environmental activities being less material, the potential influence of environmental performance on economic performance is also less important. In other words, in the low-polluting industries, the potential cost savings or revenue improvements related to environmental matters may be less important than in the high-polluting industries.

The other difference reflected in this sub-group analysis refers to PMS use. In the high-polluting industries, the relationship between PMS use and environmental performance is surprisingly not significant. Despite the fact that the number of observations is low to run a structural model containing numerous parameters (see footnote 3); this result may reflect the role of complexity and regulation. Indeed, the complexity of environmental matters being higher in high-polluting industries, PMS may reflect a broad scope of environmental issues for which the firm is not able to take action in the short run. While budgeting and incentives may focus on more attainable sphere of actions, PMS provide a larger view of environmental issues which mitigates its potential impact on environmental performance. Furthermore, the regulation being more important in high-polluting industries, firms may have already reached some level of environmental performance and thus, the potential of improvement is lower.

Third, to examine the potential influence of specific components of environmental performance on the results of our model, two analyses have been conducted. As aforementioned, three composite indices and the single-factor method were used to represent latent constructs, including environmental performance. The structural model was run using four composite indices for environmental performance. Each composite indice represented the average of the items pertaining to one of the four cells of the environmental matrix (which was not necessarily the case with the single-factor method). The results remain qualitatively unchanged. This suggests that the results are not driven by specific performance aspects and the relationships are not influenced by the number of items in each performance cell of the matrix.

Furthermore, the structural model was run by dividing the environmental performance variable into the basic dimensions of the environmental performance matrix. Table 4 presents the results of two models: (i) model A divides environmental performance based on the internal and external dimensions, and (ii) model B divides environmental performance based on the process and results dimensions. The influence of eco-control systems on the dimensions of environmental performance remains similar to the global model except for two structural paths. Indeed, the external dimension of environmental performance is (i) significantly associated with the diversity of measurement of PMS, and (ii) not significantly associated with the use of PMS. This suggests that variety and multiplicity of performance indicators are important to reflect a positive image of the firm and to maintain good relationships with stakeholders, while their use constitutes internal practices which are not visible outside the firm. Lastly, each dimension of environmental performance is not significantly associated with economic performance while the global measure of environmental performance is associated with economic performance. This result supports the basic assumption of the environmental performance matrix that each of the four aspects is necessary but not sufficient for environmental performance. Only collectively can they help a firm to be effective.

-- Insert table 4 --

5. CONCLUSION

The aim of this study was to examine the influence of eco-control systems on environmental and economic performance in manufacturing firms. In sum, the results provide adequate support for the theoretical model presented in figure 2. As expected, eco-control systems (i.e. PMS, budgeting and incentives) influence positively environmental performance which in turn influences positively economic performance. However, contrary to the expectations, only the use of PMS is associated with environmental performance, while no such relationship has been established between diversity of measurement within PMS and environmental performance.

A number of theoretical contributions and practical implications can be derived from our results. From a theoretical standpoint, this paper contributes to the management accounting and environmental management literature by providing insight into the roles and contributions of management accounting in a context of sustainable development. It consolidates the role of accounting in a context of sustainable development as a tool fostering transparency and accountability (Gray, 1992). As suggested by Mathews, (1997:481), environmental accounting, as a field of study, “must lead to action and change in the relationship between business, the stakeholders which make up society and the environment which we need to support us all”. Furthermore, this study presents a holistic view of environmental performance by integrating not only one aspect of the construct but four aspects, namely process and product improvements, stakeholder relations, regulatory compliance and financial impact, as well as environmental impacts and corporate image.

Although numerous studies have addressed issues related to environmental disclosure and reporting, little is known about other dimensions of environmental accounting, especially

eco-control. As observed by Burritt (2004), empirical research in environmental management accounting is scarce and is focused more on describing than on analyzing or critically evaluating the effectiveness of tools. Thus, this paper contributes to current literature by providing empirical data shedding some light on the current practices and application of eco-control systems in manufacturing firms. Our results also reflect the importance of integrating the environmental dimension in the management control systems to optimize environmental and economic performance.

This study has also important implications for management practices. Considering the economic performance resulting from improvements in environmental performance, managers should be aware of the importance of integrating environmental matters into the existing management control systems such as performance measurement systems, budget and incentives. More specifically, there are many ways to integrate environmental issues into the control systems: (i) developing specific performance indicators (e.g. inputs of energy, outputs of solid waste, financial impact, etc.), (ii) using those indicators frequently to monitor compliance, to support decision-making, to motivate continuous improvement and for external reporting, (iii) fixing specific goals in the budget for the environmental expenses, incomes and investment, and (iv) linking environmental goals and indicators to rewards.

This study is subject to potential limitations in terms of internal and external validity. First, for any proposed structural model, other structural models tested using the same data may suggest different relationships among latent constructs and reflect equivalent levels of fit {MacCallum, 1996 #86}. The possible existence of an equivalent model is problematic and

constitutes a limitation of the current results obtained. Second, no clear evidence of causality can be established with survey data obtained from cross-sectional analyses. Rather the evidence must be considered consistent with theoretical arguments and predicted relationships. Third, this study is static, i.e., it does not incorporate the evolution of eco-control systems and performance over time. Fourth, using the survey method to collect data creates a potential for bias due to common response. Finally, considering differences in the design and use of control systems among firms depending on their size and industry, results may not be generalized outside the scope of the current sample (i.e., medium sized Canadian manufacturing firms).

Appendix 1 Description of the sample

INDUSTRY	
SIC code	#
20 Food and kindred products	26
21 Tobacco manufactures	1
22 Textile mill products	5
23 Apparel and other textile products	5
24 Lumber and wood products	42
25 Furniture and fixture	15
26 Paper and allied products	27
27 Printing and publishing	4
28 Chemicals and allied products	17
29 Petroleum and coal products	6
30 Rubber and misc. plastics products	19
31 Leather and leather products	2
32 Stone, clay, glass, and concrete products	9
33 Primary metal industries	16
34 Fabricated metal products	25
35 Industrial machinery and equipment	31
36 Electrical and electronic equipment	20
37 Transportation equipment	26
38 Instrument and related products	4
39 Misc. manufacturing industries	3
TOTAL	303

SIZE	
Number of employees	#
< 100	7
between 100 and 499	192
between 500 and 999	65
between 1 000 and 4 999	35
> 5 000	4
TOTAL	303
AVERAGE	710

Note: The seven firms included in the 100 employees or less have been classified in accordance with the answer of the survey's respondents. These firms have been previously identified and selected in the 2004 Scott's database as firm of more than 100 employees.

Appendix 2 Questionnaire Items and Statistics of Measurement Analysis

1- PMS – diversity of measurement

Items	Initial model		Respecified model	
	Standardized loadings	R ²	Standardized loadings	R ²
Inputs of raw materials (e.g. wood, metals, synthetics, etc.)	0.458**	0.210	-	-
Inputs of auxiliary materials (e.g. glue, adhesives, chemicals, solvents, etc.)	0.496**	0.246	-	-
Inputs of energy (e.g. electricity, fuel, gas, oil, etc.)	0.620**	0.385	0.606**	0.367
Inputs of water (e.g. municipal water, spring water, etc.)	0.618**	0.382	0.610**	0.372
Installation, operation and maintenance of the physical facilities and equipment (e.g. average fuel consumption of vehicle fleet, etc.)	0.563**	0.317	0.548**	0.300
Outputs of solid waste (e.g. oil, chemical, metal, etc.)	0.647**	0.419	0.635**	0.403
Outputs of waste-water (e.g. emission of waster-water containing organic materials, etc.)	0.706**	0.499	0.704**	0.496
Outputs of air emissions (e.g. CO ₂ , SO ₂ , dust, solvents, etc.)	0.725**	0.526	0.720**	0.519
Implementation of environmental policies and programs (e.g. % of environmental targets achieved, number of employees trained, etc.)	0.805**	0.648	0.803**	0.645
Conformity with requirements or expectations (e.g. number of fines or violation, number of environmental incidents, number of environmental audits, etc.)	0.862**	0.742	0.874**	0.764
Community relations (e.g. number of complaints from public or employees, number of inquires from stakeholders, etc.)	0.840**	0.705	0.847**	0.718
Financial impacts (e.g. costs and benefits of environmental actions, etc.)	0.716**	0.512	0.718**	0.516
Indicators providing information on the local, regional or national condition of the environment (e.g. contaminant concentrations in ambient air, number of fish deaths in a specific watercourse, etc.)	0.663**	0.439	0.660**	0.436
Goodness-of-fit of the model:		$\chi^2(62) = 385.8$ p< .001 NNFI= .932; CFI=.946; RMSEA = 0.132	$\chi^2(42) = 272.2$ p<.001 NNFI= .934; CFI=.950; RMSEA = 0.135	
Cronbach Alpha		0.904	0.902	
Composite reliability:		0.916	0.916	
Variance extracted:		0.464	0.503	

Note: * Significant at the .05 level ** Significant at the .01 level.

2- PMS – use

Items	Initial model		Respecified model	
	Standardized loadings	R ²	Standardized loadings	R ²
Monitor internal compliance with environmental policies and regulations	0.903**	0.815	-	-
Provide data for internal decision-making	0.944**	0.892	-	-
Motivate continuous improvement	0.899**	0.808	-	-
Provide data for external reporting	0.767**	0.588	-	-
Goodness-of-fit of the model:	$\chi^2(2) = 3.878$ p> .001 NNFI= .994; CFI=.998; RMSEA = 0.056		-	
Cronbach Alpha	0.911			
Composite reliability:	0.932			
Variance extracted:	0.776			

Note: * Significant at the .05 level ** Significant at the .01 level.

3- Budgeting

Items	Initial model		Respecified model	
	Standardized loadings	R ²	Standardized loadings	R ²
Environmental expenses	0.876**	0.768	0.858**	0.735
Environmental investment	0.967**	0.935	0.987**	0.975
Incomes from material scrap or recycled wastes	0.452**	0.204	-	-
Goodness-of-fit of the model:	$\chi^2(0) = 0$ p> .001 NNFI= 1.0; CFI=1.0; RMSEA = 0.00		$\chi^2(0) = 0$ p> .001 NNFI= 1.0; CFI=1.0; RMSEA = 0.00	
Cronbach Alpha	0.80		0.917	
Composite reliability:	0.828		0.922	
Variance extracted:	0.636		0.855	

Note: * Significant at the .05 level ** Significant at the .01 level.

4- Incentives

Items	Initial model		Respecified model	
	Standardized loadings	R ²	Standardized loadings	R ²
Environmental indicators are important in reward systems	0.880**	0.774	-	-
Environmental performance objectives are included in the planning systems	0.921**	0.848	-	-
Environmental performance indicators are weighted on par with economic performance indicators	0.934**	0.872	-	-
Goodness-of-fit of the model:	$\chi^2(0) = 0$ p> .001 NNFI= 1.0; CFI=1.0; RMSEA = 0.00		-	
Cronbach Alpha	0.922			
Composite reliability:	0.937			
Variance extracted:	0.832			

Note: * Significant at the .05 level ** Significant at the .01 level.

5- Environmental performance

Items	Initial model		Respecified model	
	Standardized loadings	R ²	Standardized loadings	R ²
Reduction in material costs	0.695**	0.483	0.751**	0.564
Reduction in process/production costs	0.760**	0.578	0.793**	0.629
Reduction in costs of regulatory compliance	0.658**	0.432	0.683**	0.467
Increased process/production efficiency	0.820**	0.672	0.849**	0.721
Increased in productivity	0.803**	0.645	0.846**	0.716
Increased knowledge about effective ways of managing operations	0.853**	0.728	0.868**	0.753
Improved process innovations	0.842**	0.708	0.859**	0.738
Improved product quality	0.768**	0.590	0.804**	0.646
Improved product innovations	0.713**	0.508	0.763**	0.582
Organizational-wide learning among employees	0.749**	0.561	0.754**	0.569
Better relationships with stakeholders such as local communities, regulators, and environmental groups	0.619**	0.383	0.596**	0.355
Improved employee morale	0.695**	0.483	0.706**	0.498
Overall improved company reputation or goodwill	0.692**	0.479	0.672**	0.452
Filters and controls on emissions and discharges	0.253**	0.064	-	-
Residue recycling	0.299**	0.090	-	-
Goodness-of-fit of the model:		$\chi^2(86) = 559.97$ p<.001; NNFI= 0.939; CFI=0.950; RMSEA = 0.135	$\chi^2(61) = 432.3$ p<.001 NNFI= .945; CFI=.957; RMSEA = 0.139	
Cronbach Alpha		0.934	0.944	
Composite reliability:		0.933	0.949	
Variance extracted:		0.494	0.591	

Note 1: * Significant at the .05 level ** Significant at the .01 level.

6- Economic performance

Items	Initial model		Respecified model	
	Standardized loadings	R ²	Standardized loadings	R ²
Return on investment (ROI)	0.893**	0.798	-	-
Operating profits	0.963**	0.927	-	-
Cash flow from operations	0.890**	0.791	-	-
Goodness-of-fit of the model:		$\chi^2(0) = 0$ p>.001 NNFI= 1.0; CFI=1.0; RMSEA = 0.00		-
Cronbach Alpha		0.939		
Composite reliability:		0.940		
Variance extracted:		0.839		

Note: * Significant at the .05 level ** Significant at the .01 level.

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FIGURE 1 Theoretical model

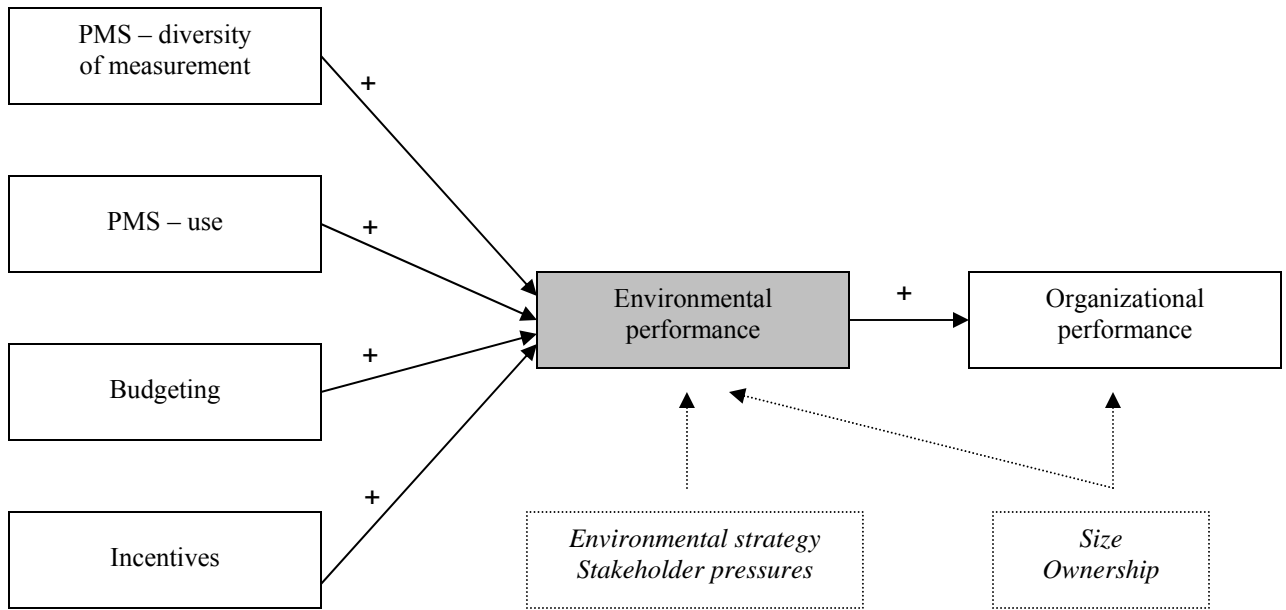


Table 1 Descriptive statistics and correlation matrix of the main constructs

	PMS – diversity of measurement	PMS – use	Budgeting	Incentives	Environmental performance	Economic performance
Descriptive statistics						
No. of items used	11	4	2	3	13	3
Theoretical range	1-7	1-7	1-7	1-7	1-7	1-7
Minimum	1.0	1.0	1.0	1.0	1.0	1.0
Maximum	7.0	7.0	7.0	7.0	6.70	7.0
Mean	4.95	5.01	4.38	3.25	3.79	4.13
Standard deviation	1.43	1.68	1.96	1.69	1.42	1.49
Median	5.20	5.50	5.0	3.2	4.0	4.33
Correlation matrix (Pearson)						
PMS – diversity of measurement	1.0					
PMS – use	0.762**	1.0				
Budgeting	0.636**	0.649**	1.0			
Incentives	0.591**	0.648**	0.590**	1.0		
Environmental performance	0.605**	0.620**	0.530**	0.587**	1.0	
Economic performance	0.062	0.067	0.091	0.117*	0.147*	1.0

Note 1: * Significant at the .05 level ** Significant at the .01 level.

Table 2 Results of the structural equation model

Hyp.	Description of path	Path coefficient	Z statistics	Conclusion
1a	PMS – diversity of measurement → Env. performance	0.169	1.334	Not supported
1b	PMS – use → Environmental performance	0.207	2.394**	Supported
2	Budgeting → Environmental performance	0.114	3.308***	Supported
3	Incentives → Environmental performance	0.173	4.256***	Supported
4	Environmental performance → Economic performance	0.129	1.961**	Supported
	Environmental strategy → Environmental performance	0.094	1.530	
	Stakeholder pressures → Environmental performance	0.174	2.514**	
	Size → Environmental performance	-0.167	1.216	
	Ownership → Environmental performance	-0.029	0.247	
	Size → Economic performance	-0.092	0.488	
	Ownership → Economic performance	0.147	0.906	
<i>R² for environmental performance = 0.315 R² for economic performance = 0.016</i>				
Goodness-of-fit indices: χ^2 (313) = 1358.225 p = 0.0; NNFI= .946; CFI=.952; RMSEA = .111				
Number of iterations: 30				

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

Table 3 Comparison of low and high-polluting industries

Description of path	Low-polluting industries (n=203)		High-polluting industries (n=100)	
	Path coefficient	Z statistics	Path coefficient	Z statistics
PMS – diversity of measurement → Env. performance	0.196	1.288	-0.079	-0.205
PMS – use → Environmental performance	0.210	2.174**	0.224	0.850
Budgeting → Environmental performance	0.141	3.110***	0.090	2.080**
Incentives → Environmental performance	0.195	3.50 ***	0.152	2.729***
Environmental performance → Economic performance	0.076	1.229	0.136	2.073**
Environmental strategy → Environmental performance	0.047	0.632	0.320	2.895***
Stakeholder pressures → Environmental performance	0.149	1.831*	0.228	1.755*
Size → Environmental performance	-0.213	-1.227	-0.324	-1.524
Ownership → Environmental performance	-0.050	-0.661	0.051	0.307
Size → Economic performance	0.133	0.761	-0.073	-0.442
Ownership → Economic performance	0.071	0.933	0.081	0.627
<i>R² for environmental performance:</i>	0.320		0.440	
<i>R² for economic performance :</i>	0.015		0.06	
Goodness-of-fit indices:	χ^2 : 1056.266 p = 0.0		767.055 p = 0.0	
	NNFI: 0.937		0.935	
	CFI: 0.945		0.942	
	RMSEA: 0.108		0.121	
	Number of iterations: 53		46	

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

Table 4 Comparison of dimensions of environmental performance

Description of path	Environmental performance dimensions			
	Model A		Model B	
	Internal	External	Process	Results
PMS – diversity of measurement → <i>Env. performance</i>	0.094	0.692***	0.183	0.223
PMS – use → <i>Environmental performance</i>	0.226**	0.016	0.175**	0.215**
Budgeting → <i>Environmental performance</i>	0.114***	0.161***	0.122***	0.123***
Incentives → <i>Environmental performance</i>	0.194***	0.147***	0.219***	0.117***
<i>Environmental performance</i> → Economic performance	0.010	0.103	0.261	-0.160
Environmental strategy → <i>Environmental performance</i>	0.088	0.013	0.052	0.123
Stakeholder pressures → <i>Environmental performance</i>	0.180**	0.151*	0.197***	0.147*
Size → <i>Environmental performance</i>	-0.257	0.319**	-0.170	-0.137
Ownership → <i>Environmental performance</i>	-0.027	-0.155**	-0.013	-0.174
Size → Economic performance		-0.003		0.079
Ownership → Economic performance		0.078		0.094
<i>R</i> ² for environmental performance:	0.279	0.523	0.315	0.342
<i>R</i> ² for economic performance :		0.027		0.031
Goodness-of-fit indices:	χ^2 : 1554.811 p = 0.0		1712.415 p = 0.0	
	NNFI: 0.949		0.948	
	CFI: 0.955		0.954	
	RMSEA: 0.106		0.107	
	Number of iterations: 104		28	

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$