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Environmental performance indicators: An empirical study of Canadian manufacturing firms

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Abstract

The aim of this exploratory study is to examine the importance of measurement and use of environmental performance indicators (EPIs) within manufacturing firms. Two research questions are investigated: (i) To what extent are firm characteristics associated with the importance of measurement of various categories of EPIs? (ii) To what extent are firm characteristics associated with global and specific uses of EPIs? More specifically, this paper examines four uses of EPIs (i.e. to monitor compliance, to motivate continuous improvement, to support decision making, and to provide data for external reporting) as well as four characteristics of firms, namely environmental strategy, International Organization for Standardization (ISO) 14001 compliance, size, and ownership. This study contributes to the environmental management accounting literature by collecting and analyzing empirical evidence that provides a better understanding of the associations among firm characteristics and EPIs.

Keywords: Environmental performance indicators; Environmental strategy; ISO 14001

1. Introduction

The aim of this exploratory study is to examine the importance of measurement and the use of environmental performance indicators (EPIs) within manufacturing firms in Canada. EPIs represent numerical measures providing key information related to environmental issues. Several reasons justify the importance of EPIs as a significant component of the environmental management system (EMS) (Eckel et al., 1992; Figge et al., 2002; Schaltegger and Burritt, 2000; Epstein, 1994). First, organizations are increasingly being held responsible for environmental actions, as reflected by the growing number of laws, regulations, and penalties in this area. Consequently, organizations are now obliged to measure, control, and disclose their environmental performance. Second, reliable EPIs are necessary to supply information for decision making while ensuring the attainment of environmental objectives. Third, the allocation of the organization's limited resources to environmental problem solving requires persuasive evidence supporting the benefits of such actions. The environmental system must therefore be able to supply information concerning the cost of reducing risks and concerning the measurement of this reduction. Lastly, as several studies have demonstrated, performance indicators are effective tools for improving business practices and organizational performance (e.g., Hoque and James, 2000; Baines and Langfield-Smith, 2003; Ittner et al., 2003; Said et al., 2003). Although no clear empirical evidence has been provided, it is believed that EPIs may also have the capacity to improve environmental performance.

In this study, we examine specifically the association among firm characteristics and two dimensions of EPIs, namely the importance of measurement and use. This choice has been motivated by numerous studies in the management accounting literature that have examined those two aspects of performance indicators (e.g., Scott and Tiesen, 1999; Ittner et al., 2003; Hoque and James, 2000; Henri, 2006a, b; Bisbe and Otley, 2004; Chenhall, 2005). Indeed, the importance of measurement and use of indicators constitute fundamental dimensions of any

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information system. While the former refers to the content of the information system (i.e., what is measured), the latter refers to the manner in which the information is used by managers (i.e., how it is used).

Two research questions are investigated: (i) To what extent are firm characteristics associated with the importance of measurement of various categories of EPIs? (ii) To what extent are firm characteristics associated with global and specific uses of EPIs? More specifically, this paper examines the importance of measurement of EPIs based on two classifications (i.e. financial/non-financial indicators, and International Organization for Standardization (ISO) 14031 classification) and four uses of EPIs (i.e. to monitor compliance, to motivate continuous improvement, to support decision making, and the provision of data for external reporting). Moreover, four firm characteristics are analyzed, namely environmental strategy, ISO 14001 compliance, size, and ownership. Two purposes motivate the choice of these factors.

First, while numerous studies have examined the relationships among those factors and various organizational practices, systems or routines (e.g., Melnyk et al., 2003; Sharma and Vredenburg, 1998; Marshall and Brown, 2003; Aragon-Correa, 1998), scant attention has been devoted to their association with EPIs. Globally, as mentioned by Burritt (2004), the empirical literature is lacking in the area of environmental management accounting (EMA).

Secondly, from a theoretical standpoint, opposite viewpoints can be provided to argue the presence or absence of relationships among the four firm characteristics and EPIs. For instance, organizations following a more active environmental strategy may place greater importance on the measurement and use of EPIs to favor the alignment of actions toward the attainment of environmental objectives. However, strategy and performance measurement are two different concepts that are not automatically linked. The literature offers various examples of lack of coherence between strategy and performance indicators within different organizations (e.g., Kerr, 1995; Ittner and Larcker, 2003). Moreover, firms implementing ISO 14001 standards may have the organizational resources and structure to more effectively collect and report environmental practices data. However, a firm may have developed various EPIs and used them intensively while not implementing ISO 14001. Similarly, ISO 14001 standards do not warrant the diversity of EPIs as their extensive use for various purposes either.

In terms of size, while larger organizations may have more resources to invest in the development of EPIs, those resources are not necessarily allocated to environmental issues. Instead, top management may assign those resources to other organizational priorities or critical uncertainties. Lastly, while public firms may face more pressure from various stakeholders to develop and report EPIs, both public and private firms face similar regulatory regimes. Hence, both types of firms may use EPIs to manage their environmental impacts. In summary, there is a need to collect and analyze empirical evidence to provide a better understanding of the associations among the four firm characteristics and EPIs.

2. Theory

2.1. Definition of EPIs

EPIs represent numerical measures, financial or non-financial, that provide key information about environmental impact, regulatory compliance, stakeholder relations, and organizational systems (Veleva and Ellenbecker, 2000; Ilinitch et al., 1998; Chinander, 2001). EPIs refer to the measurement of the interaction between the business and the environment (Olsthoorn et al., 2001). They represent the quantification of the effectiveness and efficiency of environmental action with a set of metrics (Neely et al., 1995). The indicators act as surrogates or proxies for organizational phenomena (Ijiri, 1975).

EPIs are one component of EMA. EMA can be defined as the management of environmental and economic performance through the development and implementation of appropriate environmental-related accounting systems and practices. While this may include reporting and auditing in some companies, EMA typically involves life-cycle costing, full-cost accounting, benefits assessment, and strategic planning for environmental management. The EMA is considered in turn as one component of EMS. The latter refers to the formal systems and databases that integrate procedures and processes for the training of personnel, monitoring, summarizing, and reporting of specialized environmental performance information to internal and external stakeholders of the firm (Melnyk et al., 2003). The two dimensions of EPIs that will be examined in this study, namely the importance of measurement and use, are described next.

2.2. EPIs—importance of measurement

The importance of measurement refers to the attention devoted by firms to the quantification of various environmental issues. Prior research has identified four dimensions of environmental performance that EPIs should measure: internal, external, process, and result (Lober, 1996; Ilinitch et al., 1998). To capture those four dimensions, two classifications are examined in this study: (i) financial and non-financial indicators and (ii) ISO 14031 guidelines. The distinction between financial and non-financial indicators is a widely used classification in the current literature that covers the four dimensions described above (e.g., Baines and Langfield-Smith, 2003; Said et al., 2003; Kaplan and Norton, 2001; Gosselin, 2005). The ISO 14031 guidelines also refer to the four dimensions and represent international standards that are well recognized, accepted, and implemented around the world. These two classifications are described in further detail below.

2.2.1. Financial and non-financial indicators

In spite of their capacity to present results of decisions in a comparable measurement unit, to capture the cost of trade-offs between resources and the cost of spare capacity, and to support contractual relationships and capital markets, financial measures have been criticized for several reasons (Atkinson et al., 1997; Epstein and Manzoni, 1997; Fisher, 1992; Kaplan and Norton, 1992, 1996). Those criticisms have led to the emergence of non-financial measures. In comparison with non-financial measures, financial measures are perceived as too historical and backward looking, lacking predictive ability to explain future performance, rewarding short-term or incorrect behavior, lacking actionability, lacking timely signals, being too aggregated and summarized to guide managerial action, reflecting functions instead of cross-functional processes, and providing inadequate guidance to evaluate intangible assets (Ittner and Larcker, 1998). However, the link between improvement in non-financial measures and profits is unclear and sometimes impossible to assess directly.

In summary, both types of information capture different aspects of the various facets of organizational effectiveness. The ends and outputs are revealed by financial measures while the means and processes are reflected by non-financial measures. Hence, both types of information are useful for managers. In terms of environmental performance, given the nature and diversity of the factors measured (e.g. monetary resources invested in the environment, atmospheric emissions, waste water, the number of environmental audits, the number of environmental non-compliance incidents), EPIs generally integrate both financial and non-financial measures.

2.2.2. ISO 14031 guidelines

A second possible grouping of EPIs is the classification according to ISO 14031 guidelines. This standard, a sub-category of ISO 14001, concerns the evaluation of environmental performance. It proposes guidelines for the development of monitoring and measurement tools that evaluate the efficiency of an environmental system. This standard proposes three categories of EPIs (Bennett and James, 1998; Marshall and Brown, 2003):

(1) Environmental condition indicators (ECIs): defined as specific expressions that provide information about the local, regional, national, or global condition of the environment. Those measures include (i) receptor indicators (e.g. ecotoxicity, biological oxygen demand, (ii) sustainability indicators (e.g. emissions of a substance per volume of production or per unit of value added), and (iii) proxy ECIs (i.e. indicators that express emissions and waste data in terms of their capacity to cause environmental damage).
(2) Operational performance indicators (OPIs) provide information about the environmental performance of an organization's operations. They include (i) input of materials, energy, and services, (ii) operation of facilities and equipment and logistics, and (iii) output of products, services, waste, and emissions.
(3) Management performance indicators (MPIs) provide information about management's efforts to influence an organization's environmental performance. Four sub-categories are identified: (i) implementation of policies and programs, (ii) conformity of actions with requirements or expectations, (iii) community relations, and (iv) environment-related financial performance.

2.3. EPIs—use

Despite considerable interest in the different uses of performance indicators in the management accounting literature (e.g. Atkinson et al., 1997; Henri, 2006a, b; Ittner et al., 2003; Simons, 2000), little attention has been devoted to the various types of uses of EPIs in the EMA literature (notable exceptions include Bennett and James (1998) and Briassoulis (2001). Indeed, despite a considerable body of literature examining the generic use of various EPIs (i.e., global and undifferentiated use of indicators), the specific manner in which those indicators are used by managers as control mechanisms, motivation tools, or communication devices has been overlooked empirically. Four types of uses are reflected in the accounting literature, namely monitoring, attention-focusing and signaling, decision making, and external reporting. From the overlap between the 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.

2.4. Firm characteristics

In this study, the relationships among four contextual factors and EPIs are examined, namely environmental strategy, ISO 14001 compliance, size and ownership. First, the environmental strategy is operationalized in the literature using several typologies (e.g., Ullmann, 1985; Hunt and Auster, 1990; Roome, 1994; Hart, 1995; Clarkson, 1995). These classifications group organizations according to the level of deployment of their organizational strategy at the environmental level. Although some classifications are more detailed, the categorization used by Ullmann (1985) advantageously presents a dichotomy of antithetical levels of corporate environmental strategy: active and passive. Accordingly, passive organizations are described as having little or no managerial involvement, little or no environmental management and integration, little or no employee involvement and training, and few or no resources allocated to environmental performance. Conversely, active organizations have medium or high managerial involvement, partial or complete integration of the environment function, moderate or substantial

employee involvement and training, and moderate or considerable resources allocated to the attainment of environmental objectives.

More specifically, various elements can be used to determine whether an organization follows an active or passive environmental strategy based on components such as filters and controls on emissions and discharges, residue recycling, use of environmental arguments in marketing, environmental aspects in administrative work, periodical environmental audits, purchasing manuals with ecological guidelines, environmental seminars for executives, environmental training for firms' employees, total quality program with environmental aspects, pollution damage insurance, environmental management manuals for internal use, environmental analysis of a product's life cycle, participation in government-subsidized environmental programs, and sponsorship of environmental events (Aragon-Correa, 1998).

Secondly, developed by the ISO, the ISO 14000 series of standards addresses various aspects of environmental management (Veleva and Ellenbecker, 2000). The ISO 14001 specifies the need for an EMS that represents a structured approach to setting and attaining environmental objectives and targets, and demonstrating that they have been achieved by management (Veleva and Ellenbecker, 2000). This voluntary set of standards is intended to encourage organizations to systematically address the environmental impacts of their activities (Pringle et al., 1998). In this study, we examine whether the firms are ISO-compliant or not. Lastly, in this study, size is defined as the total number of employees within the firm. Ownership refers to the public or private nature of the organization.

3. Study design

3.1. Data collection

Data were collected using a survey design. A random sample comprised of 1500 Canadian manufacturing organizations was formed based on the Scott's Manufacturing 2004 database. The sample contains organizations that have 100 employees or more, and report sales of over $20 million annually. These criteria are intended to ensure that organizations are large enough for organizational and strategic variables to apply (Miller, 1987) and that management control systems are sufficiently developed (Bouwens and Abernethy, 2000).

The questionnaire was first validated using a pre-test administered to various academics and managers. This pre-test validated an understanding of each of the measurement instruments. Then, the questionnaire was sent to the CEO or another member of the top management team (COO or senior vice-president). A letter presenting 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.

The final sample comprised 1447 organizations (considering wrong addresses, organizations that moved, etc). In total, 303 usable questionnaires were received, for a response rate of 20.9%. On average, organization size was 710 employees and the respondents had on average 13.7 years of experience working for their organization. Appendix A presents a complete profile of the respondents. An analysis of the non-response bias was performed 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 for the non-respondents) did not reveal any significant differences in the responses obtained for the main constructs of the study (e.g. EPIs and firm characteristics).

3.2. Measurement of constructs

Table 1 presents the instruments used to measure the various constructs as well as the descriptive statistics and the correlations matrix. Respondents were asked about the importance of measurement of EPIs using an instrument developed based on the ISO 14031 standard (panel A). The instrument included 13 items from the three categories described above ranging on a seven-point Likert-type scale. Respondents were asked about the use of EPIs with an instrument developed by Bennett and James (1998) containing four items (panel B) and measured on a seven-point Likert-type scale. Prior work suggests that the various uses of management control systems are likely to be correlated or exhibit overlap (Shields and Shields, 1998; Hansen and Van der Stede, 2004). Considering that our objective is to examine the association among firm characteristics and specific uses of EPIs, we remove the common factor among the various uses of EPIs and focus on its "unique" element. In order to focus on the uniqueness associated with each use, we follow the work of Hansen and Van der Stede (2004). Specifically, we use the residuals from regressing each use of EPIs on the other three as key variables in the analyses. Appendix B presents the initial work to determine whether the four uses were correlated yet sufficiently unique to justify analysis by itself.

Respondents were asked about the type of environmental strategy implemented by their organizations using an instrument developed by Aragon-Correa (1998), which includes 14 items (panel C). Answers were measured using a seven-point Likert-type scale. Organizations that have an above average mean score of environmental practices compared with the total respondent population are

Table 1
Measurement of variables and descriptive statistics

(A) EPIs—importance of measurement
(i) Specific measures (*Note*: 1 = not important at all, 7 = very important)

EPIs	Mean	Std. Dev.	Median	Min.	Max.	ISO 14031 classification			Fin/non-fin classification	
						ECI	OPI	MPI	Fin	Non-Fin
Conformity with requirements or expectations	5.70	1.92	6.0	1	7			X		X
Inputs of energy	5.50	1.67	6.0	1	7		X			X
Community relations	5.20	2.06	6.0	1	7			X		X
Outputs of solid waste	5.13	1.83	6.0	1	7		X			X
Outputs of air emissions	5.10	2.02	6.0	1	7		X			X
Financial impact	4.92	1.94	5.0	1	7			X	X	
Installation, operation, and maintenance of the physical facilities and equipment	4.91	1.68	5.0	1	7		X			X
Outputs of waste water	4.79	2.37	6.0	1	7		X			X
Inputs of raw materials	4.76	2.22	5.0	1	7		X			X
Inputs of water	4.76	2.12	5.0	1	7		X			X
Implementation of environmental policies and programs	4.72	2.04	5.0	1	7			X		X
Inputs of auxiliary materials	4.60	2.08	5.0	1	7		X			X
Indicators providing information on the local, regional, or national condition of the environment	3.75	2.31	4.0	1	7	X				X
Mean	4.91	1.39	5.20	1	7					

(ii) Categories of measures (significant at the .05 level, **significant at the .01 level)

ISO 14031 indicators	Mean	Std. Dev.	Median	Min.	Max.	Correlation matrix (Pearson)		
						MPI	OPI	ECI
Management performance indicators (MPI)	5.13	1.68	5.50	1	7	1		
Operational performance indicators (OPI)	4.97	1.40	5.29	1	7	.70**	1	
Environmental condition indicators (ECI)	3.75	2.31	4.0	1	7	.61**	.54**	1

Financial/non-financial indicators	Mean	Std. Dev.	Median	Min.	Max.	Correlation matrix (Pearson)	
						Fin	Non fin
Financial	4.92	1.94	5.0	1	7	1	
Non-financial	4.91	1.39	5.08	1	7	.65**	1

(B) EPIs—use (*Note*: 1 = not used at all, 7 = used to a very great extent)

Use of environmental performance indicators	Mean	Std. Dev.	Median	Min.	Max.
Monitor internal compliance with environmental policies and regulations	5.31	1.91	6.0	1	7
Motivate continuous improvement	5.16	1.78	6.0	1	7
Provide data for internal decision-making	5.01	1.79	5.0	1	7
Provide data for external reporting	4.48	2.05	5.0	1	7
Mean	4.99	1.68	5.50	1	7

(C) Environmental strategy (*Note*: 1 = not important at all, 7 = very important)

Environmental strategy	Mean	Std. Dev.	Median	Min.	Max.
Filters and controls on emissions and discharges	5.76	1.49	6.0	1	7
Residue recycling	5.40	1.60	6.0	1	7
Use of natural environmental arguments in marketing	3.63	1.77	4.0	1	7
Natural environmental aspects in administrative work	3.80	1.62	4.0	1	7
Periodic natural environmental audits	4.44	1.96	5.0	1	7

Table 1 (*continued*)

(C) Environmental strategy (*Note*: 1 = not important at all, 7 = very important)

Environmental strategy	Mean	Std. Dev.	Median	Min.	Max.
Purchasing manual with ecological guidelines	3.31	1.75	3.0	1	7
Natural environmental seminars for executives	3.30	1.60	3.0	1	7
Natural environmental training for firm's employees	3.81	1.75	4.0	1	7
Total quality program with natural environmental aspects	4.16	1.81	4.0	1	7
Pollution damage insurance	3.84	2.01	4.0	1	7
Natural environmental management manual for internal use	4.17	2.06	4.0	1	7
Natural environmental analysis of product life cycle	3.32	1.78	3.0	1	7
Participation in government-subsidized natural environmental programs	2.94	1.72	3.0	1	7
Sponsorship of natural environmental events	2.87	1.67	3.0	1	7
Mean	3.91	1.25	4.0	1	6.50

(D) ISO 14001

	N	%
Step 1: Not being considered	93	30.7
Step 2: Future consideration	50	16.5
Step 3: Assessing suitability	17	5.6
Step 4: Planning to implement	15	4.9
Step 5: Currently implementing	22	7.3
Step 6: Successfully implemented	106	35.0
Total	303	100

(E) Size

	Mean	Std. Dev.	Median	Min.	Max.
Number of employees (log)	2.57	.42	2.48	1.08	4.34

(F) Ownership

	N	%
Public	119	39.3
Private	184	60.7
Total	303	100

considered to be active, whereas organizations with a mean score below the average are considered to be passive. The ISO 14001 compliance was measured using an instrument developed by Melnyk et al. (2003). Respondents were asked to identify the stages of development of the ISO 14001 standard into six steps. Accordingly, organizations situated in steps five (*currently implementing*) and six (*successfully implemented*) are considered ISO 14001 compliant (panel D). Size was measured by computing the natural log of the number of employees (panel E). This measure is preferable to financial measures that complicate the comparison of organizations with differing accounting methods (Chenhall, 2003). Organizations situated above the average size are considered larger, whereas those situated below the average size are considered smaller. Lastly, respondents were asked to indicate whether their organization was privately owned or publicly traded (panel F).

3.3. Data analysis

Two types of analysis are used to examine the associations among the four contextual factors and the importance of measurement and use of EPIs. First, a correlation matrix is used to provide preliminary evidence of the relationship between constructs. Then, analyses of variance (ANOVAs) are performed to compare the mean score of EPIs using two groups for each contextual factor: active or passive environmental strategy; ISO compliance or not; large or small business; private or public ownership.

4. Results

4.1. Descriptive results

Table 1 presents the importance of measurement of various EPIs and their classifications. The results presented

in panel A suggest that overall, organizations devote moderate importance to the various EPIs (4.91/7; s.d. 1.39). Specifically, the indicators on which the managers devote the most importance to are: those that measure conformity with requirements or expectations (5.70), inputs of energy (5.50), community relations (5.20), outputs of solid waste (5.13), and outputs of air emissions (5.10). Indicators that are considered least important are those providing information on the local, regional or national condition of the environment (3.75), measuring the inputs of auxiliary materials (4.60), implementation of environmental policies and programs (4.72), inputs of water (4.76), inputs of raw materials (4.76), and outputs of waste water (4.79). The large standard deviation for the majority of the indicators indicates the dispersion of results in the sample.

According to the ISO 14031 classification, the results suggest that organizations devote most importance to measurement of MPIs (5.13; s.d. 1.68) followed closely by OPIs (4.95; s.d. 1.39). Organizations place little importance on measurement of ECIs (3.75; s.d. 2.31). The correlation matrix (Table 1, panel A) shows that these three categories of indicators are significantly correlated. These results suggest that these categories are unique but also complementary. The results for the financial and non-financial classifications show that organizations place similar importance on the measurement of these two groups of indicators (4.92 s.d. 1.94 vs. 4.91 s.d. 1.39). The correlation matrix reveals a significant correlation between those categories, which also reflects their uniqueness and complementarities.

The results of panel B suggest that overall, organizations tend to make moderate use of EPIs (4.99/7; s.d. 1.68). More specifically, monitoring internal compliance with environmental policies and regulations (5.31) is the most frequent use of environmental indicators in organizations, followed by continuous improvement (5.16) and providing data for internal decision making (5.01). The use of environmental performance measurement systems for external reporting purposes (4.48) is less common in organizations.

4.2. Comparative results

Table 2 presents the correlation matrix between EPIs dimensions and organizational characteristics while Table 3 presents the results of ANOVAs.

4.2.1. Environmental strategy

First, the correlation matrix indicated that environmental strategy has a strong correlation with the importance of measurement (.675, $p<.01$) and use of EPIs (.668, $p<.01$). Moreover, the results of ANOVAs also suggest that the type of environmental strategy is associated with the importance of measurement and the use of EPIs. Accordingly, panel A suggests that organizations that adopt an active environmental strategy place more importance on the measurement of EPIs than organizations that adopt a passive environmental strategy (5.59 vs. 4.08; $p<.01$). The same finding can also be observed in relation to different components of ISO 14031 classifications and financial/non-financial indicators ($p<.01$). Regarding the use of EPIs (panel B), the results suggest that organizations which adopt an active environmental strategy *globally* use EPIs significantly more than organizations with a passive strategy (5.86 vs. 3.97; $p<.01$). Specifically, using the residuals, the results suggest that two *individual* uses differ significantly. Indeed, organizations reflecting an active environmental strategy appear to use EPIs more intensively to motivate continuous improvement ($p<.05$) and to provide data for decision making ($p<.05$) than organizations reflecting a passive strategy. No difference is observed for the two other uses (i.e. to monitor compliance and to provide data for external reporting).

Those results are in line with two streams of research. First, the management accounting literature provides considerable evidence supporting the relationship between organizational strategy and the measurement and use of performance indicators (e.g. Abernethy and Guthrie, 1994; Gosselin, 2005; Hoque, 2004; Said et al., 2003). Second, the environmental management literature provides insights into the link between environmental strategy and organizational routines, such as the measurement and use of EPIs (e.g. Hunt and Auster, 1990; Doonan et al., 2002;

Table 2
Correlation matrix

	EPIs—importance of measurement	EPIs—use	Environmental strategy	ISO 14001	Size	Ownership
EPIs—importance of measurement	1.0					
EPIs—use	.758**	1.0				
Environmental strategy	.675**	.668**	1.0			
ISO 14001	.331**	.446**	.410**	1.0		
Size	.187**	.190**	.162**	.203**	1.0	
Ownership	.278**	.237**	.195**	.300**	.131*	1.0

ISO 14001 and ownership are dichotomous variables.
*Significant at the .05 level; **Significant at the .01 level.

Table 3
Associations among firms' characteristics and EPIs

(A) Importance of measurement of EPIs (*$p<.05$, **$p<.01$)

	Environmental strategy			ISO 14001 compliant			Size			Ownership		
	Active	Passive	Sig.	Yes	No	Sig.	Larger	Smaller	Sig.	Public	Private	Sig.
Number of firms	161	142		128	175		133	170		119	184	
Environmental condition indicators	4.46	2.87	**	4.24	3.39	**	3.90	3.63	n.s.	4.15	3.49	*
Operational performance indicators	5.56	4.19	**	5.42	4.65	**	5.13	4.80	*	5.37	4.67	**
Management performance indicators	5.94	4.15	**	5.87	4.60	**	5.47	4.87	**	5.76	4.73	**
Financial indicators	5.50	4.21	**	5.43	4.53	**	5.20	4.71	*	5.34	4.65	**
Non-financial indicators	5.60	4.06	**	5.45	4.51	**	5.14	4.73	*	5.40	4.59	**
Global	5.59	4.08	**	5.44	4.52	**	5.14	4.73	*	5.40	4.60	**

(B) Use of EPIs (*$p<.05$, **$p<.01$)

	Environmental strategy			ISO 14001 compliant			Size			Ownership		
	Active	Passive	Sig.	Yes	No	Sig.	Larger	Smaller	Sig.	Public	Private	Sig.
Number of firms	161	142		128	175		133	170		119	184	
Monitor internal compliance with environmental policies and regulations[a]	.07	−.08	n.s.	.15	−.11	*	.06	−.05	n.s.	−.02	.01	n.s.
Motivate continuous improvement[a]	.10	−.11	*	.08	−.06	n.s.	.11	−.09	*	−.02	.02	n.s.
Provide data for internal decision-making[a]	.09	−.10	*	.07	−.05	n.s.	−.02	.02	n.s.	.09	−.06	n.s.
Provide data for external reporting[a]	.01	−.02	n.s.	.001	−.0008	n.s.	−.08	.07	n.s.	.25	−.17	*
Global[b]	5.86	3.97	**	5.80	4.37	**	5.40	4.70	**	5.55	4.66	**

[a]Considering the objective to analyze the specific uses of EPIs, those comparisons are conducted using the 'unique' portion of each use. As previously mentioned, the uniqueness is obtained by using residuals from regressing each use of EPIs on the other three uses.
[b]Considering the objective to analyze the global use of EPIs, those comparisons are conducted using both 'unique' and 'common' portion of each use, i.e. the data provided by the respondents.

Henriques and Sadorsky, 1999). In sum, those streams of research suggest that organizations that adopt an active environmental strategy are more likely to place greater importance on the measurement of EPIs and to use them extensively (i) to favor the alignment of actions toward the attainment of environmental objectives, (ii) to motivate their senior executives to become involved in environmental management, (iii) to promote employee involvement, and (iv) to support the decision-making process.

4.2.2. ISO 14001 compliance

The correlation matrix indicated a correlation between ISO 14001 compliance and both the importance of measurement (.331 $p<.01$) and the use of EPIs (.446 $p<.01$). The results of ANOVAs also suggest that compliance to the ISO 14001 standard is associated with the importance of measurement and use of EPIs. Accordingly, the ISO-compliant firms place greater importance on the measurement of EPIs than do the non-ISO-compliant firms (5.44 vs. 4.52; $p<.01$). The results obtained are similar for the two classifications ($p<.01$). Regarding the use of EPIs, the results suggest that the ISO-compliant firms *globally* use EPIs significantly more than the non-ISO-compliant firms (5.80 vs. 4.37; $p<.01$). Specifically, the results suggest that only one *individual* use differs significantly (to monitor compliance $p<.05$) while no difference is observed for the three other uses.

Thus, firms implementing ISO 14001 standards will likely have the organizational resources and structure to more effectively collect environmental practices data (Marshall and Brown, 2003). The existence of an EMS thus suggests a higher level of top management commitment to environmental issues, and a greater likelihood that the firm will establish goals for environmental impact reduction as well as measuring programmatic investments focused on achieving those goals (Marshall and Brown, 2003). In addition, the ISO-compliant firms are more likely to be aware of EPIs than those that are not. Indeed, they are more likely to be aware of the ISO 14031 guidelines that propose a wide range of EPIs. Furthermore, since the ISO 14001 standard requires that each of the organizational processes has at least one objective and an indicator that measures the attainment of this objective it is probable that ISO-compliant firms place more importance on the

measurement of EPIs, which they use more than non-ISO-compliant firms to monitor internal compliance with policies and regulations.

4.2.3. Size

The correlation matrix indicated a correlation between size and both importance of measurement (.187, $p<.01$) and use of EPIs (.190, $p<.01$). The results of ANOVAs also suggest that size is associated with the importance of measurement and the use of EPIs. Thus, larger firms place more importance on the measurement of EPIs than do smaller firms (5.14 vs. 4.73; $p<.05$). Regarding classifications, only the difference in ECI scores is not significant. In the case of use, the results suggest that *globally* larger firms use EPIs more than smaller firms do (5.40 vs. 4.70; $p<.01$). However, this finding does not apply to the four types of use. Specifically, only the use of EPIs to motivate continuous improvement is significantly different between the two groups ($p<.05$).

Those results are in line with common findings in the management accounting literature suggesting that larger organizations are more likely than smaller organizations to develop and use management control systems (Chenhall, 2003). This phenomenon also seems to be observed with respect to environmental management control systems, particularly EPIs. Indeed, large organizations generally have more resources to invest in pollution control, prevention technologies, and the development of environmental performance measurement systems (Marshall and Brown, 2003). Furthermore, larger size is associated with a rise in problems related to social control, communication, and coordination (Merchant, 1981). Organizations thus face an exponential increase in the number of channels that require a flow of information for coordination purposes, which hinders communication (Merchant, 1981). Consequently, as organizations grow, they tend to implement a more administratively oriented control strategy that involves increased structuring of activities, more formalized communication and greater use of standardized information for the evaluation of managerial performance (Bruns and Waterhouse, 1975). These factors encourage large organizations to devote more attention to the measurement of performance indicators and to use them as part of organizational routines. Externally, large organizations are more visible to external stakeholders, such as environmental interest groups, the community and governments, groups which may all exert pressure on these organizations (Ullmann, 1985). Hence, large firms may devote more attention to the measurement of EPIs to help manage environmental issues.

4.2.4. Ownership

The correlation matrix indicated that ownership is correlated with importance of measurement (.278, $p<.01$) and use of EPIs (.237, $p<.01$). Moreover, the results of ANOVAs also suggest that ownership is associated with the importance of measurement and use of EPIs. Consequently, publicly owned organizations place more importance on the measurement of EPIs than privately owned organizations (5.40 vs. 4.60; $p<.01$). This observation also applies to all the classifications. Regarding the use, publicly owned organizations *globally* use EPIs more than private organizations do (5.55 vs. 4.66; $p<.01$). Specifically, the results suggest that one *individual* use differs significantly, namely external reporting ($p<.05$). No difference is observed specifically for the three other uses.

Those results concur with arguments and conclusions provided in past research. For instance, Klassen and McLaughlin (1996) note that strong environmental management results in significant positive stock market performance. This result is corroborated by Deutsch (1998), who observes that eco-efficient organizations reward shareholders with good financial performance. Thus, stronger environmental performance can improve the value of the firm and attract new stockholders (Melnyk et al., 2003). This phenomenon is confirmed by the advent of several mutual funds that select stocks for portfolios based on their environmental performance. Consequently, public organizations that want to implement a green strategy that can help create value for shareholders are likely to control and measure the attainment of their environmental objectives by developing EPIs.

In addition, Doonan et al. (2002) show that two of the three main sources of pressure reported by environmental managers are the government and the general public. Public organizations are increasingly responding to these stakeholders' concerns and transmitting more information through obligatory disclosure of financial statements to shareholders, than are, for example, private organizations. Therefore, in response to pressures from these external stakeholders, public organizations are more likely than private organizations to want to disclose environmental information. Environmental performance measurement systems are thus an excellent means for public organizations to gather environmental information and disclose it to external stakeholders.

5. Conclusion

The objective of this exploratory study was to identify associations among firm characteristics and the importance of measurement of EPIs and their use. The results of this study suggest three main conclusions. First, the importance of measurement of EPIs is associated with (i) firms having a more active environmental strategy, (ii) ISO 14001 compliant firms, (iii) larger firms, and (iv) public firms. Second, the *global* use of EPIs is also associated with a more active environmental strategy, ISO 14001 compliance, larger firms and public firms. Third, the *specific* uses of EPIs are associated with different firm characteristics: (i)

to monitor compliance is associated with ISO-compliant firms, (ii) to motivate continuous improvement is associated with an active environmental strategy and larger firms, (iii) decision making is associated with an active environmental strategy, and (iv) external reporting is associated with public firms.

This study contributes to the development of knowledge in the field of EMA. First, it enriches the empirical literature, which is currently underdeveloped in this area (Burritt, 2004), by providing evidence of associations among various firm characteristics and EPIs. In addition, this study provides a better understanding of EPIs by differentiating and specifically examining two fundamental dimensions: the importance of measurement and use. Also, this study differentiates four uses of EPIs and suggests that global use and specific use of EPIs are not associated with the same firm characteristics.

This study has also important business implications. Indeed, managers should be aware that the measurement and use of EPIs: (i) support and communicate the environmental strategy throughout the organization, (ii) support and ensure conformity of environmental processes helping organizations to obtain and maintain the ISO 14001 certification, (iii) formalize complex environmental processes and procedures, (iv) decentralize and support environmental information systems, and (v) contribute to meeting stakeholders expectations.

This study is subject to potential limitations. First, this study encompasses four organizational factors influencing the measurement and use of EPIs in manufacturing firms. Measurement of different firm characteristics could lead to other interesting results. Moreover, the interaction among firm characteristic has not been examined and could lead to different results. Second, the number of items used to measure the diversity of measurement of EPIs may appear small and imprecise. However, considering the scope of the sample, a generic definition of indicators (i.e. output of solid waste, inputs of energy) has been used to allow comparison between different industries. The use of more precise indicators in specific industries could lead to different results. Third, using the survey method to collect data can create a potential bias due to common response and social desirability. Finally, considering differences in the regulations and market settings among different countries, results may not be generalized outside the scope of the current sample (i.e., small-to-medium sized manufacturing firms in Canada).

This study opens many avenues for future research. As previously mentioned, several other firm characteristics such as organizational structure, organization life cycle, presence of a green leader in the organization, pressure from stakeholders, global strategy of the organization, and the structure of the board of directors could be investigated to determine their influence on EPIs. Moreover, the interaction among the different firm characteristics could also be explored. In addition, other dimensions of EPIs such as information quality and EPIs updating process could also be examined to determine how they are influenced by firm characteristic. Furthermore, the link between EPIs and existing database compatibility, information providers, software tools, and information characteristics (e.g. aggregation, timeliness) could also be investigated. Considering the particular economic structure in Canada, specific attention could also be devoted to small businesses to extend the discussion related to the measurement and use of EPIs in this type of organization. Lastly, in addition to considering firm characteristics, future research could assess the influence of EPIs on environmental actions put forth by managers and employees, along with the environmental and economic performance of organizations.

Appendix A

Description of the sample (Table A1).

Table A1
Description of the sample

Industry SIC code	#
20 Food and kindred products	26
21 Tobacco manufacturers	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	15
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	4
Total	303
Size Number of employees	#
<100	7
Between 100 and 499	192
Between 500 and 999	65
Between 1000 and 4999	35
>5000	4
Total	303
Average	710

Appendix B

Analysis of the uses of EPIs (Table B1).

Table B1
Analysis of the uses of EPIs

(A) Correlation matrix (Pearson) (significant at the .05 level, **significant at the .01 level.)

	(i)	(ii)	(iii)	(iv)
(i) Monitor compliance	1.0			
(ii) Continuous improvement	.811**	1.0		
(iii) Decision-making	.761**	.830**	1.0	
(iv) External reporting	.636**	.671**	.658**	1.0

Preliminary conclusion: All four uses are significantly correlated ($p < .01$).

(B) Factor analysis

(i) Principal components

Components	Eigenvalue	Variance (%)	Cumulative (%)
1	3.189	79.73	79.73
2	.413	10.32	90.05
3	.240	6.0	96.05
4	.158	3.95	100.0

Preliminary conclusion: Data suggest a one-component factor structure.

(ii) One-factor structure

EPIs use	Factor loading	Uniqueness
(i) Monitor compliance	.901	.188
(ii) Continuous improvement	.932	.132
(iii) Decision-making	.913	.166
(iv) External reporting	.822	.325

Conclusion: Although the four use load on one factor, each use has some "uniqueness", i.e. a portion of the variance unexplained by the common factor.

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