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Full Length Research Paper

Environmental management in Brazil: A survey evaluating current practice and performance in the industrial sector

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The rapid urban development observed in major cities and the resulting environmental impacts have made the lessening of these impacts a key objective in sustainable development and companies have been required to consider economic, environmental and social consequences in their cultures, strategies and decision-making processes. The goal of this paper was to evaluate to what extent manufacturing companies have been responding to these challenges. The study was performed with a survey that considered 63 manufacturing firms of different sizes and from a variety of sectors located in Brazil. The results of the research and the statistical analysis performed on these results suggested that the actions taken by industries to face their environmental challenges have generally been effective and surpassed the environmental demands enforced by the law in multiple ways. The hypotheses tested as part of this experiment allowed the researchers to verify that companies with ISO 14001 certification had better environmental performance than those without it, as expected. It was also possible to verify that the discipline imposed by forms of certification other than ISO 14001 have had positive influence on the environmental performance. The research results confirmed that multinational companies had better environmental performance than Brazilian national firms. On the other hand, firm size did matter in terms of environmental performance, but no significant difference was perceived among manufacturing companies in different industrial sectors.

Key words: Environmental performance, industrial pollution, sustainable development, survey, Brazil.

INTRODUCTION

The environmental impacts of urban expansion have been extensively analysed, illustrating the adverse effects this expansion has had on air, water, and soil (Brehemy, 1992; Camagni et al., 2002; Pare´s-Franzi et al., 2006; Wu et al., 2010). In fact, environmental degradation has intensified as production and consumption have expanded (Jabbour and Santos, 2008), which has made the reduction of the environmental impacts resulting from accelerated urban expansion a key objective in sustainable development (Pare´s-Franzi et al., 2006). As a result, businesses have generally been pushed to incurporate economic, environmental and social performance measures into their cultures, strategies and decision-making processes (Brent and Visser, 2005).

Environmental issues can usually be expected as a result of urban human concentrations and dense economic activity. For instance, emissions in the São Paulo Metropolitan Area (the most industrialised region in Brazil) amounted to 1.6 million tons of carbon monoxide, 382 thousand tons of hydrocarbons, 376 thousand tons of nitrogen oxides, 63 thousand tons of particulate

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material and 26 thousand tons of sulphur oxides in 2009 (CETESB, 2010). It is true that most of those emissions have arisen from motor vehicle (Tavares et al., 2011). However, public authorities have also put pressure on the industrial sector to minimise pollution problems in the area.

With these issues in mind, the main purpose of this paper was to analyse to what extent the Brazilian industries have been responding to current environmental challenges. This goal was realised through a survey that considered63 national and multinational industries of different sizes and from different sectors, located predominantly in the São Paulo State. The results allowed the researchers to understand the current environment-related practices actually employed by the industries under study and how these practices have contributed to their current environmental performance.

Sustainable development can be defined as meeting the needs of current generations without impeding future generations from meeting theirs (Smith and Rees, 1998). Sustainable development cannot be achieved without the effective implementation of environmental management in companies, and it has become critical to their survival in a competitive globalised world (Preston, 2001). Thus, business sustainability requires the integration of the three pillars of sustainable development (social justice, economic efficiency and environmental performance) into a company's operational practices. Firms have been increasingly required by external stakeholders to commit to and report on the respective sustainability performance of their operational initiatives (Labuschagne et al., 2005) as a way to enhance to the goal of becoming high performance or "world-class" organisations (Molefe et al., 2011).

According to Srebotnjak (2007), many different definitions of environmental performance exist. However, the ISO 14001 standard – Environmental Management System Specification and Use – defines environmental performance as *"measurable results of an organization's management of its environmental aspects"* (ISO, 2004, p.3). ISO 14001 is also the international standard that permits organisations to obtain an environmental management system certification. As a specification standard, it is part of the ISO 14000 family, a full set of ISO environmental procedures. ISO 14001 enables firms to pursue continuous environmental improvements using the PDCA (plan-do-check-act) model (Angell and Klassen, 1999) and also illustrates how an environmental policy simplifies environmental planning, implementation and operation by continuously checking company's environmental performance and taking corrective actions when required. The central assumption of this approach is that by improving its manufacturing processes, a firm can provide better environmental practices, improving its financial and operational performance as a result (Gavronski et al., 2013; Nawrocka and Parker, 2009; Silva and Medeiros, 2004).

According to May et al. (2002), companies should understand their respective environmental performance to formulate proper environmental policies, plans, and programs for their activities. Some scholars have developed research on the correlation between environmental and business performance. For instance, results from Klassen et al. (1996), King and Lenox (2001) and Koner and Cohen (2001) have indicated that businesses with better environmental performance and less pollution show a higher financial performance.

To help organisations measure their environmental performance, the International Organisation for Standardisation (ISO) has developed the ISO 14031 standard – Environmental Management and Environmental Performance Evaluation and Guidelines (ISO, 1999). According to ISO, the environmental performance evaluation is *"an internal process and management tool designed to provide management with reliable and verifiable information on an on-going basis to determine whether an organisation's environmental performance is meeting the criteria set by the management of the organisation".*

Therefore, environmental performance evaluation is considered a process or a tool dealing with the utilisation of indicators (Jasch, 2000; Tsoulfas and Pappis, 2008). ISO 14031 also proposes a methodology to measure the environmental performance of companies in terms of definitions, working structures, and different types of quantitative indicators such as environmental, management and operational performance indicators. Note that indicators are the main tools used in this standard, and are defined as the *"specific expression that provides information about an organization's environmental performance"* (ISO, 1999, p.7).

Despite an increasing focus on various environmental performance indices at the national, sectorial and company levels (Srebotnjak, 2007; Mayer, 2008), the environmental performance measurement remains one of the greatest challenges to organisations (Johnston et al., 2001) because the uncertainty of measurements in relation to the indicators used is often neglected. On the other hand, the uncertainty of raw data is a critical issue, because an indicator can reveal a true picture of environmental performance only if it is based on good-quality data (Perotto et al., 2008).

In addition, the basic objective of environmental performance evaluation through the use of indicators is to assure that industrial activities evolve in line with sustainable principles that are acceptable to society and the environment. In practice, environmental performance indicators can be used in several decision situations by internal and external stakeholders to assure a continuous process of environmental impact reduction in products or processes. Internal stakeholders require detailed indicators to monitor and control the environmental performance of their products and activities as part of their

business processes. Conversely, external stakeholders need broader indicators that can enable them to pressure the company for continuous improvement of its environmental performance (Thoresen, 1999).

The main purpose of this paper was to investigate to what extent the industries located in Brazil have been responding to current environmental challenges. To that end, the authors decided to identify the key environmental practices being executed by industries in the area and how those practices could express the environmental performance of each. The following hypotheses (H) were also posed to investigate the relationships between a firm's environmental performance and some of its key characteristics:

H1: Companies with ISO 14001 certification have better environmental performance than those without it.

Gavronski et al. (2013) have indicated that ISO 14001-certified Brazilian companies have created a more integrated approach to environmental management by adopting practices that favour their environmental performance. Therefore this paper tested the selected research sample by confirming through hypothesis H1 that ISO 14001 certification had a positive impact on environmental measurement.

H2: The discipline imposed by certifications other than ISO 14001 positively influences environmental performance.

Oliveira and Pinheiro (2009) have confirmed the importance of minimising the resistance to change caused by ISO 14001 certification in Brazilian companies. This paper verified that the adoption of other types of certification (like ISO 9001, for instance) could positively impact the implementation of environmental practices that result in better environmental performances.

H3: Multinational companies have a better environmental performance than Brazilian national firms.

Many managerial practices used by multinational companies are progressively being emulated by the local manufacturing community in developing countries (Cruz and Pedrozo, 2009; Melnyk et al., 2003). Therefore this study investigated whether this statement applied to the environmental practices lead to environmental performance.

H4: Firm size matters to environmental performance.

It has been postulated that larger companies have higher environmental awareness than smaller firms (Jabbour et al., 2010). This paper verified if the environmental performance of larger companies was significantly better than that observed in medium and small firms.

H5: Companies belonging to the auto industry have better environmental performance when compared to other industrial segments.

There is a conceivable expectation in Brazil that environmental performance in the auto industry is far better than that observed in other manufacturing sectors as a result of the stringent requirements imposed by multinational auto assemblers on their entire supply chains (Vanalle et al., 2011). To see if this fact could be confirmed, this study tested whether the auto industry's environmental performance was significantly different from that identified in other manufacturing segments.

RESEARCH METHODOLOGY

A survey was conducted as per Forza (2002) to evaluate the environmental practices employed by industries in Brazil and the listed research hypotheses. For that purpose a population frame was composed by all the industrial companies associated with the São Paulo Industrial Federation. Among them 150 industrial firms were randomly chosen by means of a systematic sampling where one firm was selected for every 10 existing in the population frame.

A questionnaire with closed questions was then sent by e-mail to the person in charge of environmental management in industrial firms forming the research sample. The researchers subsequently contacted these persons by phone to encourage completion of the questionnaire. Of the questionnaires sent, 63 or 42% were fully and adequately answered and used to support the analysis and findings in this paper.

The questionnaire was comprised 11 questions that covered: a) current environmental licence status (1 question); b) solid and liquid waste disposal methods (4 questions); c) environmental consideration in product design, manufacturing processes and purchasing (3 questions); d) potential pollution problems affecting the firm's neighbourhood (1 question) and e) environment as a key strategic factor (2 questions). Each question posed five statements describing different approaches to each of the subjects being considered. Those statements described typical practices ranging from those with a high level of environmental awareness and commitment (that is, best practices) to those involving no environmental concern at all (that is, worst practices). However, as a result of the questionnaire testing, the sequence of practices presented to the interviewees changed from question to question to avoid answering bias. As an example, one of the questions posed to the interviewees is shown in Figure 1. Note that letters (A) to (C) added to this example indicate best environmental practice (A) and worst environmental practice (E).(B), (C) and (D) were used to show the 3 intermediate alternatives. These letters were not included in the questionnaire sent to the firms.

The returned questionnaires were analysed to verify the adequacy and consistency of the answers provided by the interviewees. From the 72 questionnaires received, 9 were discarded due to apparent inconsistencies. The remaining 63 were tabulated and their data were processed using SPSS – Statistical Package for Social Science for Windows Version 13 (SPSS Inc., Chicago, IL, USA).

Although the literature provides several alternatives to measuring the environmental performance of a company (Verfaillie and Bidwell, 2000; OECD, 2002, 2005; Huppes and Ishikawa, 2005; Styles et al., 2009a, 2009b), this study proposes an environmental performance evaluation method based on the best environmental practices actually used by organisations. This approach identified the environmental practices being utilised by a given company in predefined areas and granted a certain number of points to each

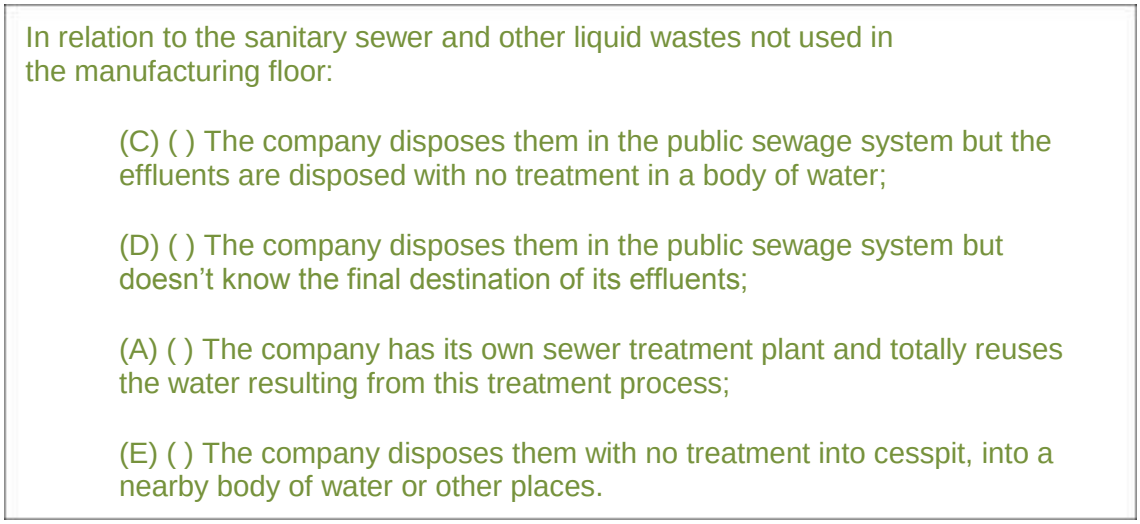

Figure 1. One example of a question posed to the interviewees.
Letters (A) to (E) added to this example to indicate best (A) and worst (E) environmental practices. (B), (C) and (D) represent statements with intermediary environmental concerns. These letters were not included in the questionnaire sent to the firms.

practice. A maximum number of points was given to those practices reflecting high environmental commitment and a minimum number of points was granted to those practices reflecting no environmental concerns at all. Proportional points were given to different situations in-between those two extremes. By adding all of the points obtained by a particular company, it was possible to calculate a score that could serve as a measure of that company's environmental performance. Hence, to measure a company's environmental performance, 5 points were granted to each question for which a best practice was selected by the interviewee. On the other hand, 1 point was granted whenever the answer indicated a non-environmental practice. 4, 3 or 2 points were granted for the 3 intermediate alternatives depending on the statement chosen. The overall environmental performance of a given company was measured by adding the points obtained from the 11 questions, ranging from a minimum of 11 possible points to a maximum of 55.

Comparisons of environmental performances of different sets of firms were required to test the 5 hypotheses proposed by this study. Those evaluations required, where appropriate, descriptive statistics and hypotheses testing using two samples mean comparisons through an independent t-test and several sample mean comparisons using a One-way ANOVA. Significant coefficients were identified at $p<.05$ as per Dancey and Reidy (2007).

RESULTS AND DISCUSSION

As alluded to already, the survey was answered by 63 companies with the following characteristics: a) ownership: 23 were subsidiaries of multinational companies operating in Brazil and 40 were national firms; b) size: 15 were small (less than 100 employees), 26 were medium (between 100 and 499 employees), 13 were large (between 500 and 1,999 employees) and 9 were very large (more than 2,000 employees); c) industrial sector: 17 belonged to the automotive sector, 5 to the electrical component manufacturing sector, 25 to the metal-mechanical sector and 16 to 12 other industrial sectors; and d) certifications: 25 of the researched companies had both ISO 9001 and ISO 14001 certifications, 30 were only ISO 9001 certified, 2 were only ISO 14001 certified and 6 had no ISO certifications.

The survey results were initially evaluated on a question-by-question basis with the objective to identifying the most common environmental practices used by the companies under study and those practices' influence on a company's environmental performance. Statistical analyses were then developed to evaluate if variables such as ownership, size, industrial sector or quality and environmental certification could induce different environmental performance in the researched companies, a practice called the performance comparison.

Question-by-question analysis

After analysing the returned questionnaires it was possible to group the results as shown in Figure 1, where A represents the statement reflecting the best environmental practices and E the worst. B, C and D signify statements with intermediary environmental concerns. The numbers shown in each column indicate the number of companies that reported the use of each environmental practice presented on the left (A, B, C, D or E). For instance, in terms of the first environmental aspect analysed (adequate licensing), 53 of the 63 researched companies indicated that they had all the required environmental permits (statement A), 3 stated that they

did not have any environmental licences at all (statement E) and 1 noted that it was still in the process of obtaining the appropriate licences(statement D).

The first question posed to the interviewees asked about the current status of their companies' environmental licences. 59(94%) of the companies indicated that their licences were in full compliance with local legislation, indicating that being legally accountable was a major concern among industries in the research area. Of the remaining 4 companies, 1 affirmed that it was in process of fixing licensing issues and only 3 small companies stated that they did not have the necessary documentation.

In terms of dangerous solid wastes, 15 firms (24%) indicated that they did not generate any such waste. Of the remaining 48, 47(98%) said they provided adequate waste disposal in accordance with local regulations and under direct supervision of environmental authorities. The other company stated that it disposed of dangerous solid wastes according to the legal requirements, but with no previous authorisation from environmental authorities. No other environmental issues were reported in this section of the questionnaire.

19 companies (30%) mentioned that they did not generate any industrial effluents in addition to conventional sewage material. Of the other 44, 24(55%) indicated that they performed an adequate treatment prior to returning effluents to the environment because they did not reutilise them in the manufacturing process. 6 firms (14%) performed some reutilisation and the remaining 14 (32%) reutilised all effluents for further use. Note that all of the researched companies performed an adequate effluent disposal and only the degree of effluent reutilisation varied.

The results on sewage disposal were not as positive. 43 companies (68%) either had their own treatment plant with which to reutilise water (13 firms or 20%) or dispose of sewage effluent into the public system where proper treatment could be performed (30 companies or 48%). 10 (16%) said they disposed sewage effluents into the public system, but the sewage ended up in a nearby river with no treatment at all. The remaining 10(16%) indicated they disposed of sewage materials into a cesspit or directly into a nearby river.

As far as non-dangerous solid waste are concerned (manufacturing, general garbage and organic materials), 42 companies (67%) reported that they performed waste separation and send it for recycling. 61(97%) had their scrap and inorganic garbage removed by third parties for adequate disposal in authorised landfills, while organic wastes were removed by the municipal garbage collection services. Only two firms stated that they sent both organic and inorganic wastes to an unauthorized location (Table 1).

In terms of product design, 56 companies (89%) indicated that they accounted for environmental aspects when designing their products. However, only 31(49%) considered the environmental impacts of disposing of a product after its useful lifespan. The remaining 24(38%) assumed that the product's destination was the final consumer's responsibility. Only 6 firms (10%) did not consider environmental issues when designing their products.

On the other hand, manufacturing process design is fared much better. 57 companies (90%) considered raw material and energy conservation along with toxic material elimination, reduction (of both quantity and toxicity) of wastes and gaseous emissions when designning their manufacturing processes. Only 6 firms (10%) stated that they considered environmental constraints in their manufacturing process as long as these constraints did not adversely affect their manufacturing costs.

Purchasing processes were also questioned in the survey. 58 firms (92%) considered environmental aspects to some extent during their purchasing process. Of these, 12 companies (19%) indicated they purchase materials and services exclusively from vendors with some type of environmental certification, while other 15(24%) adopted the same approach but only for items with high pollution potential. The remaining 31(49%) stated that they had a preference for environmental certified vendors, provided that the vendors had the same commercial conditions as the non-certified sources. Only 5 (8%) firms declared that they did not consider environmental aspects in their purchasing processes.

The next question was about the relationship a company had with its community in terms of its pollution potential. 48 firms (76%) reported not having any type of problem. The other 15(24%) indicated that minor complaints from neighbours had been reported, but the situation had been settled with no adverse impact on community relationships.

In terms of the environmental practices used by the companies under study, 59 firms(93%) confirmed that these practices were the result of the company's own initiative, inspired by the understanding that: a) environment protection is one of the pillars of sustainability (41 companies or 65%); b) modern companies should be concerned with protecting the environment (16 or 25%) and c) this is a concept already adopted by most of a company's competitors (2 or 3%). 3 firms (5%) indicated that environmental practices had been imposed by their clients and only one company stated that it was not concerned with environmental issues.

42 companies (77%) confirmed that environment protection was one of their key strategic elements as perceived by both internal and external stakeholders. 20 (32%) declared that they were concerned with environmental aspects but that these aspects were not part of their strategic thinking. Only one company stated that it was not concerned with environmental issues.

As stated earlier, a given company's environmental

Table 1. Number of companies indicating environmental practices currently in use (A represents a statement reflecting the best environmental practices and E the worst. B, C and D represent statements with intermediary environmental concerns).

		Adequate environmentallicensing	Adequate solid waste disposal	Adequate effluent disposal	Adequate sewage disposal	Adequate non-industrial garbagedisposal	Environmental considerations inproductdesign	Environmental considerations inmfg.processdesign	Environmental considerations inpurchasing	Relationship with neighbouringcommunities	Environmental protection as itsowninitiative	Environmental protection as akeystrategicdirection
Best environmental practice	A	59	15	19	13	42	32	53	12	48	41	27
Intermediary environmental practice	B	0	47	14	30	14	12	4	15	15	16	15
	C	0	1	6	4	2	12	0	11	0	2	0
	D	1	0	24	6	3	1	6	20	0	3	20
Worst environmental practice	E	3	0	0	10	2	6	0	5	0	1	1
	Total	63	63	63	63	63	63	63	63	63	63	63

performance was measured by granting 5 points to each question for which a best practice was cited by the interviewee and 1 point whenever a non-environmental practice was selected. 4, 3 or 2 points were granted as the other 3 possible alternatives depending on the statement selected. A company's environmental performance was measured by adding the points obtained from the 11 questions. Applying those assumptions to the 11 questions answered by each of the 63 companies included in the survey, it was possible to calculate each company's environmental performance. The following descriptive statistics on the 63 firms' environmental performance were calculated using SPSS for Windows 13.0 software: a) a performance range with a: minimum of 29 (compared to a possible minimum of 11) and a maximum of 53 (against a possible maximum of 55); b) a sample distribution mean of 45.1; c) a sample distribution median of 46.0; d) a sample distribution standard deviation of 5.04; e) a 95% confidence level interval for the a mean of $43.8 < \mu < 46.4$. The statistical analysis also indicated that the environmental performance was normally distributed about the mean.

The environmental performance of the industrial companies located in the research area showed that the environmental concerns represented a great deal more than conventional corporate speech. Environmentally-friendly practices have been actually used to a great extent by the majority of industrial firms in the area, regardless of their size, ownership or industrial sector they belong. These statistics were not the result of law enforcement, because many of the practices described in the questionnaire were not imposed by environmental laws. Some examples of these practices are described as follows a) There is no legal obligation for companies to select and recycle non-industrial garbage, but 42 out of the 63 researched companies (67%) selected and recycled the garbage anyway, b) There is no provision in the law requiring environmental considerations when defining manufacturing processes. However, 53 firms (84%) indicated that they were concerned with the conservation of materials and energy, elimination of toxic wastes and reduction of toxicity and quantity of wastes and emissions when they developed the fabrication processes for their products, c) Environmental legislation does not impose rules on a company relationship with the community in the vicinity of its plants. However, 48 firms (76%) expressed deep concern about maintaining the neighbouring public's immunity to pollution problems caused by their manufacturing operations. Therefore, it seems that increased environmental awareness could be considered a possible source for several of the environmental initiatives taken by local industries.

Performance comparisons

H1: The data collected in the survey enable some interesting comparisons. Initially, it would be reasonable to expect that companies with ISO 14001 certification would display better environmental performance than

Table 2. SPSS output for the independent t-test on the equality of the means in *H1.*

		Levene´s test for equality of variances		t test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval	
Performance	Equal variances assumed	9.61	.003	-2.472	61	.016	-3.0463	1.23224	-5.5103	-0.5822
	Equal variances not assumed			-2.688	55.03	.009	-3.0463	1.13311	-5.3170	-0.7755

those without it (Fortunski, 2007). This statement was tested as a research hypothesis to verify if it could be accepted with a significant level of confidence. In fact, calculating the environmental performance of the ISO-certified companies they yielded a 46.9 mean and a 3.0 standard deviation. The mean and standard deviation of the other firms were 43.8 and 5.8 respectively. To verify if there was an actual significant difference between the two means, an independent t-test was conducted to compare the environmental performance means of the 27 ISO 14001 certified companies and the other 36 firms. Using SPSS for Windows 13.0 it was possible to obtain the results shown in Table 2.

Table 2 shows that the independent t-test for 61 degrees of freedom demonstrated that if the null hypo-thesis was true the result would be improbable because $t(61) = 2.47$; $p < .016$. In conclusion, the research hypothesis was accepted because there was actually a difference between the environmental performance of the ISO 14001-certified companies and the non-certified firms, as initially expected.

H2: Does the discipline imposed by certifications other than ISO 14001 influence environmental performance? To test this hypothesis the companies with no environmental certification were grouped together, and a comparison between the environmental performances of the 30 ISO 900-certified and the other 6 non-certified firms was performed within this set. The following results were obtained: a) The environmental performance mean of the ISO 9001-certified companies was 44.8, with a 4.2 standard deviation; b) The other firms had a 38.7 mean and a 9.8 standard deviation. To verify if a significant difference between the two means existed, an independent t-test was also conducted as shown in Table 3.

The independent t-test for 34 degrees of freedom could demonstrated that if the null hypothesis was true, the results would be improbable because $t(34) = 2.54$; $p < .016$. In conclusion, the research hypothesis was accepted. In the absence of ISO 14001 certification, there was a difference in the environmental performance of the ISO 9001-certified companies and the other firms.

H3: Another research hypothesis was related to ownership: do multinational companies have better environmental performance than Brazilian national firms? The results of testing this hypothesis are as follows: a) The environmental performance mean of the 23 multinational companies was 47.6, with a 2.6 standard deviation, b) The 40 national firms had a 43.7 mean and a 5.5 standard deviation. The significant difference between the two means was also verified through an independent t-test as shown in Table 4.

The independent t-test for 61 degrees of freedom demonstrated that if the null hypothesis was true, the results would be very improbable because $t(61) = 3.27$; $p < .002$. In conclusion, the research hypothesis was accepted because there was a statistically significant difference in the environmental performances of the multinational and national companies.

H4: Does size matter when considering environmental performance? To test this hypothesis, the companies under study were divided into four groups: 9 very large, 13 large, 26 medium and 15 small. The descriptive statistics for those groups were: a) very large - mean 47.4 and standard deviation 4.0; b) large - mean 47.1 and standard deviation 2.6; c) medium - mean 45.6 and standard deviation 4.6; and d) small - mean 41.1 and standard deviation 5.2. To verify if a significant difference existed among those means, a One-way ANOVA test was performed using SPSS for Windows 13.0. The results are shown in Table 5.

The F test for 3 (between the groups) and 59 (within the groups) degrees of freedom verified that if the null hypothesis was true, the result would be very improbable because $F(3;59) = 5.49$; $p < .002$. In conclusion, the research hypothesis was accepted because there was a statistically

Table 3. SPSS output for the independent t-test on the equality of the means in *H2.*

		Levene´s test for equality of variances		t test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval	
Performance	Equal variances assumed	12.338	.001	-2.54	34	.016	6.16667	2.42717	1.23405	11.0993
	Equal variances not assumed			1.518	5.384	.185	6.16667	4.06369	-4.0589	16.39230

Table 4. SPSS output for the independent t-test on the equality of the means in *H3.*

		Levene´s test for equality of variances		t test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval	
Performance	Equal variances assumed	9.375	.003	3.265	61	.002	4,00217	1.22572	1.55120	6.45315
	Equal variances not assumed			3.893	59.284	.000	4.00217	1.02817	1.94501	6.05934

significant difference in environmental perfor-mance depending on the size of the company under consideration. However, *post hoc* analysis considering multiple comparisons as per Tuckey's HSD (honestly significant differences) test, indicated that significant differences existed at the

.05 level only between the small companies and all the other firms. No differences were significant between the very large, large and medium size firms.

H5: This research also investigated a widespread idea in the literature indicating that companies belonging to the auto industry have had better environmental performance compared to other industrial segments due to the stringent environ-mental requirements imposed by auto assemblers on their entire supply chains. To test this hypothesis the firms under study were divided into four segments: 17 belonging to the automotive sector, 5 to the electrical component manufac-turing sector, 25 to the metal-mechanical sector and 16 to 12 other industrial sectors. The descriptive statistics for those groups were: a) automotive – mean 44.2 and standard deviation 5.9; b) electrical component manufacturing – mean 46.4 and standard deviation 3.16; c) metal-mechanical – mean 44.7 and standard deviation 4.4; and d) all others – mean 46.4 and standard deviation 5.2. To test if a significant difference existed among those means, a One-way ANOVA test was once again conducted, which produced the results shown in Table 6.

The F-test for 3 (between the groups) and 59 (within the groups) degrees of freedom demon-strated that the null hypothesis could not be rejected because $F(3;59) = .69$; $p < .561$. In conclusion, the research hypothesis was rejected because there was not a statistically significant difference in environmental performance accor-ding to sector.

Table 7 shows the 5 hypotheses considered in this research and the results from the statistical tests performed on them. In summary, this research suggested that the industries in the research area with ISO 14001 certification had a better environmental performance than those without it, as expected. The same conclusion was extended to those companies with ISO 9001-certified quality systems even in the absence of ISO 14001. It was possible to conclude that multi-national firms implemented more environmental friendly practices compared to Brazilian national companies. Size mattered to environmental

Table 5. SPSS output for a one-way ANOVA test on *H4*.

		Sum of square	df	Mean square	F	Sig.
Performance	Between groups	343.190	3	114.397	5,492	.002
	Within groups	1,229.032	59	20.831		
	Total	1,572.222	62			

Table 6. SPSS output for a one-way ANOVA test on *H5*.

		Sum of square	df	Mean square	F	Sig.
Performance	Between groups	53.361	3	17.787	.691	.561
	Within groups	1,518.861	59	25.743		
	Total	1,572.222	62			

Table 7. Summary of the tested hypotheses and their respective results.

Hypotheses		Status	Reason
H1	Companies with ISO 14001 certification have better environmental performance than those without it.	Accepted	The independent t-test demonstrated that if the null hypothesis was true, the results were improbable because $t(61) = 2.47$; $p < .016$.
H2	The discipline imposed by certifications other than ISO 14001 positively influences environmental performance.	Accepted	The independent t-test verified that if the null hypothesis was true, the results were improbable because $t(34) = 2.54$; $p < .016$.
H3	Multinational companies have better environmental performance than Brazilian national firms.	Accepted	The independent t-test established that if the null hypothesis was true, the results were very improbable because $t(61) = 3.27$; $p < .002$.
H4	Firm size matters.	Accepted	The F test (ANOVA) corroborated that if the null hypothesis was true, the results were very improbable because $F(3;59) = 5.49$; $p < .002$.
H5	Companies belonging to the auto industry have better environmental performance than those in other industrial segments.	Rejected	The F test (ANOVA) proved that the null hypothesis could not be rejected because $F(3;59) = .69$; $p < .561$.

performance, but only when comparing small companies to the other sizes considered. Finally, no significant environmental performance differences could be perceived among different sectors of industry.

Conclusion

The accelerated urban expansion observed in the research area has made the reduction of the resulting environmental impacts a crucial objective to sustainable development. The industrial sector has been challenged by environmental authorities to make a significant contribution to efforts to reduce pollution in the area, by imposing stringent environmental requirements.

However, the results of the survey presented in this study suggested that general actions taken by industries to combat the environmental challenges have been effective and surpassed the mere shallow environmental wording. Companies have shown more environmental concern than the “must do” requirements imposed by legislation, as the actual practices observed transcend legal demands in several aspects. In fact, the results indicated that the environmental performance of the companies considered in this research reached a 46-point mean (against a maximum of 55). Furthermore, several of the environmental practices reported by the firms were broader and more environmentally friendly than those required by local environmental authorities. The research also highlighted the general characteristics of the companies most committed to the utilisation of best environmental practices. These companies are ISO

14001- certified or had at least an ISO 9001 certification and were usually multinational firms that were not small in size and belonged to no specific industrial sector.

The findings presented here are also subject to some limitations. The validity of the proposed environmental performance measures should be verified by further research comparing it with similar indices that are already being used. This step was not performed here because proposing a new method to measure environmental performance was not the central focus of this work. Second, the initial questionnaire answered by the researched firms should be followed by a more in-depth interview, in which much more detailed information could be obtained to shed light on specific points not covered by the present survey and create a more meaningful analysis. Future research will consider this approach to report on amore detailed analysis.

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