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ISO 14001 certified plants in Brazil – taxonomy and practices

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ABSTRACT

Research on taxonomies has helped in shedding light on similarities between firms in a particular group and differences between each group. However, few studies have analyzed how operations managers of manufacturing firms in emerging countries adopt diverse strategies of environmental management, with diverse operational practices and results. This study fills this gap by proposing a taxonomy for ISO 14001-certified plants, describing the differences for each group for a set of key variables related to internal and external perspectives. For this purpose, we conducted a survey of ISO 14001-certified manufacturing plants in Brazil, in a restricted set of industries including chemical, manufactured metal products, and electronics. A sample of 99 plants was analyzed using multivariate data analysis techniques, such as principal component analysis (PCA), cluster analysis, and analysis of variance (ANOVA). We have identified three clusters, according to their motivations to certification: internal focus, external focus, and holistic group. Internal focus companies are characterized by their emphasis on internal operations and resources. External focus companies deal with social pressure and institutions that regulate the environment. Holistic companies place high value on all motivation dimensions regardless if they are internal or external. We present an illustrative example related to the Holistic group. Companies in this group present a more efficient use of raw materials and inputs as well a higher integration with suppliers and external research and development (R&D) centers. This group combines external actions with internal results regarding environmental management. Thus, the results suggest that external integration and the improvement of internal processes efficiency allow a more integrated approach in environmental practices, resulting in better environmental performance. On the other hand, companies with the external focus strategy tend to have lower environmental performance and lower levels of operational practices linked to the environmental management.

1. Introduction

Pressures from clients and society have led manufacturing companies to develop efforts and adapt their processes in order to reduce or eliminate the negative impact of their operations on the environment. Options such as cleaner production, environmental management systems, and pollution control systems have been used as tools to address these needs (Cervelini and Souza, 2009; Klassen and Whybark, 1999a). Environmental Management Systems (EMS), of which the ISO 14000 family of standards is an example (Gavronski et al., 2008), tend to impact mitigation and create conditions for sustainable operations, matching expectations of stakeholders and a growing number of interested people (Cagno et al., 1999). Increasing interest in protecting natural environment against industrial pollution means that EMS and technologies related to sustainable operations are more than an option, becoming, in fact, an inevitable choice (Alberti et al., 2000). Factors such as environmental protection laws, increasing cost of raw materials energy production, and natural resources policies have impacted on companies' economic systems, which in turn affect companies' performance and competitiveness and demand revisions in management paradigms (Ferrer, 2008). The development and diffusion of EMS represent a significant part of this commitment to rethink conventional management wisdom (Cagno et al., 1999).

Numerous studies in the literature have investigated the major reasons for companies adopting EMS and corporate social responsibility practices (CSR) (Bansal, 2005; Bansal and Hunter, 2003; Fryxell and Szeto, 2002; Gavronski et al., 2008; Massoud et al., 2010; Oliveira et al., 2010; Zhu et al., 2007) and their impacts on

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firm performance (Cervelini and Souza, 2009; Heras-Saizarbitoria et al., 2011; Jacobs et al., 2010; McGuire et al., 1988; Melnyk et al., 2003; Montabon et al., 2007; Nawrocka and Parker, 2009). However, there are still knowledge gaps about the relationship among motivation for EMS implementation, environmental practices and results especially in companies located in emerging economies such as Brazil. More than 600 companies have been certified in the ISO 14001 standard in Brazil, according to the Brazilian Institute for Metrology (INMETRO). Past studies have looked at why companies in emerging economies such as Brazil adopted an EMS based in the ISO 14001 standard (Gavronski et al., 2008; Oliveira et al., 2010). In this study, we will use a taxonomy related to ISO 14001 motivations to identify strategic groups and compare the environmental operational practices and environmental performance between these strategic groups.

In operations strategy literature, several studies have tried to identify and understand how companies can be classified in terms of strategic decisions. Miller and Roth (1994) proposed a taxonomy of operations strategy based on the competitive priorities. Later replications of this taxonomy and other related studies were conducted by Menor et al. (2001), Frohlich and Dixon (2001), and Zhao et al. (2004). The *Journal of Operations Management*, in 2000, dedicated a special issue about companies' strategic configurations, with studies focusing on operations strategy's categories of decision. Most configuration studies gather data from developed countries. One exception is the work of Kim and Lim (1988), which used perceptual data from 54 Korean top managers to provide a numerical taxonomy of strategic groups. In the field of environmental and sustainable operations, very few studies attempted to find strategic groups of companies and environmental issues in developing countries. Klassen and Whybark (1999a,b) identified a numerical taxonomy in the developed United States. No study was found, though, about taxonomy of companies adopting ISO 14001 in developing countries. Thus, what are the strategic groups that emerge from motivation of companies in emerging countries, such as Brazil, to adopt ISO 14001? How different are these strategic groups in terms of environmental operational practices and environmental performance?

Therefore, this paper has two objectives. First, we obtain a numerical taxonomy that classifies the environmental operation strategies of manufacturing plants according to the major reasons for adoption of ISO 14001 by Brazilian companies. Second, we describe the differences among the strategic groups we obtained in the numerical taxonomy regarding environmental practices and results. To achieve our first objective, we rely on resource-based view (RBV) and institutional theories to conceptualize the major reasons Brazilian companies adopted such environmental management system. Following the recommendations from Bozarth and McDermott (1998), we have integrated operations strategy literature with the business strategy literature, by using such mainstream explanations (RBV and institutional), using the motivations to the ISO 14001 certification to classify manufacturing companies according to their environmental strategy.

From an academic perspective, our main contribution is to shed light on the strategic patterns followed by companies in emerging countries when adopting ISO 14001. By doing this, we provide a source for comparison with other related studies on companies from developed countries (Klassen and Whybark, 1999a,b). In this paper we present a numerical taxonomy of companies adopting ISO 14001 in emerging countries. Our work will identify and distinguish characteristics of groups of companies and serve as a basis for future studies also developing numerical taxonomies of ISO 14001 and other related EMS. From a social-level perspective, our contribution is to find out how companies in developing countries perceive and act when facing the social challenges related to caring for the environment and natural resources. By revealing such characteristics of companies, decision makers in developing countries can design public policies to help companies achieving higher levels of environmental performance.

The next section introduces a brief review of the related literature. In the methodology section, we describe the major methodological procedures. Then, we present results in two parts: first we show the outcome from the survey, and second we present a qualitative case related to the proposed taxonomy. Finally, we discuss major findings, conclusions, and limitations of the study.

2. Literature review

2.1. Environmental management system and ISO 14001 certification

Environmental management systems can be viewed as operational management tools helping the development and execution of business strategies. Echoing Wheelwright (Wheelwright, 1984), Angell and Klassen (1999) argue that operations strategic decisions are developed through structural decisions (regarding facilities, capacity, process technology and vertical integration) and infrastructural decisions (related to human resources, quality systems and supply). In this sense, an environmental management system provides a set of tools able to establish changes through mechanisms and techniques ordered and is essential to improve performance and assist in identifying and managing environmental risks and obligations (Epstein and Roy, 1998). Moreover, a management system based on organizational accountability, management controls, and systems analysis and planning may have a higher degree of proactivity from the stakeholders (Klassen, 2001) and can be a tool to offset the costs of improving environmental performance and reduce the trade-off between competitiveness and legal compliance (Porter and van der Linde, 1995).

The international standard that allows an organization to obtain such an environmental management system certification is ISO 14001. ISO 14001 is the specification standard, part of a set of standards aimed at environmental management systems, called the ISO 14000 family. A company can obtain ISO 14001 certification for each site (manufacturing facilities or service facilities) by independent bodies. ISO 14001 standard also allows companies to seek continuous improvements based on the PDCA (plan-do-check-act) model (Angell and Klassen, 1999). Thus, this model, also known as the PDCA cycle, enables managers to establish a continuous improvement of its environmental impact. An environmental policy facilitates planning, implementation and operation, checking and taking corrective action and review of the management system, and provides guidance for the construction of a management system aimed at the achievement of environmental goals (Melnyk et al., 2003). The basic assumption of this approach is that by improving the manufacturing process, the company would develop better environmental management practices and improve their financial and operational performance, contrary to the traditional belief that environmental performance must be improved at the expense of the remaining performance dimensions (Jacobs et al., 2010; McGuire et al., 1988; Melnyk et al., 2003; Montabon et al., 2007; Nawrocka and Parker, 2009).

2.2. Classification schemes of environmental operations

Klassen and Whybark (1999a,b) proposed a typology of operations technologies employed by companies to address the following environmental activities: pollution prevention, environmental management system, and pollution control. In this context, the mission of operations is to create eco-efficient capabilities linked to these respective environmental activities. Other authors

suggested alternative typologies of environmental impact of operations (Hart, 1995; Hart and Dowell, 2010; Shrivastava, 1995). Pollution prevention requires structural investments that involve changing the operations and improving the environmental performance throughout the productive process. Doing so can generate significant economic benefits to the company. For this reason, Hart (1995) indicated that pollution prevention programs are similar to total quality management (TQM) programs. Both programs try to eliminate losses and wastes in the whole process, given that pollution and the excessive use of materials and energy can be considered process losses. Hence, the resources and capabilities that a firm develops for the introduction of TQM might be useful in a pollution prevention program. Environmental management systems are infrastructural procedures that affect how the operations are managed. They might include the formalization of operating processes, cross-functional coordination, involvement of stakeholders, monitoring, internal and external disclosure of results, training, certification, and other activities related to the environmental impact of the company (Klassen and Whybark, 1999b). Pollution controls are the structural investments that deal with final process emissions after they have been generated. They do not always reduce the total amount of pollutants that are released or discarded, but they do reduce the risk associated with them (Klassen and Whybark, 1999b).

Angell and Klassen (1999) suggest that there are two environmental strategy perspectives: *external constraint* and *component*. Firms that treat the environment as an external constraint will make environmental decisions independently of the operational decisions. Since these decisions made separately are locally optimized, it is unlikely they also are globally optimal. Firms that treat the environment as an operational component recognize the strategies as legitimate operational factors that must be integrated in all operational decisions. Azzone and Noci (1998) proposed a typology of environmental policies that include five orientations: evangelist, proactive, responsive, reactive, and unresponsive. Klassen and Whybark (1999a) identify a taxonomy of three managerial orientations with regard to their environmental policies: obedience, opportunism, and leadership. Table 1 shows a summary of the classification schemes available in the literature. In general, we identified two sets of classifications: technology and environmental managerial orientation. These sets of classifications are neither mutually exclusive nor redundant.

However, most studies about classification schemes on environmental management practices are either conceptual or rely on what companies are currently doing. We propose a different approach to evaluate, classify, and identify groups of companies and their environmental strategies: the reasons motivating these companies to adopt ISO 14001 environmental management system. Because motivations reveal the strategic intentions of managers in pursuing the certification of the EMS, we will identify the environmental strategy of these companies.

2.3. Motivations for ISO 14001 certification

There are many reasons for companies to adopt environmental management systems such as ISO 14001 (Gavronski et al., 2008). Instead of discussing each of these potential reasons, we rely on the work of Bansal (2005) and organize them around two broad theoretical categories: reasons stemming from a resource-based view perspective and reasons stemming from an institutional theory perspective. We also believe that both approaches are able to explain how companies develop their practices and achieve expected results after the EMS implementation.

2.3.1. Institutional theory

Institutional theory's key assumption is that organizations are strongly related and affected by their environment, becoming isomorphic with it (Meyer and Rowan, 1977). DiMaggio and Powell (1983) defined isomorphism as a process of homogenization in which organizations in a given field become constrained by the environment, limiting their ability to change and forcing them to adopt common practices.

Based on the basic tenets of institutional theory, we argue that companies may adopt ISO 14001 to comply with social norms and to adjust to environmental practices adopted by other companies (Fryxell and Szeto, 2002). For instance, the act of showing off their ISO 14001 certification seals in all products and marketing campaigns suggests that companies are concerned about how stakeholders view companies' environmental procedures. In addition, third party certification programs help legitimate companies' decision and actions, influencing public opinion. Massoud et al. (2010) conducted a study in the food industry in Lebanon and found evidence suggesting that companies pursue environmental management practices in order to enhance their image. Sometimes, having a legitimate environmental program in course becomes a necessary condition for companies that want to compete on the market, if most competitors have already adopted an EMS. In this case, not adopting ISO 14001 means that the company does not qualify for selling its product in the market. The ways by which companies look for external legitimacy characterizes an external motivation to certify the EMS under ISO 14001 standards.

2.3.2. Resource-based view

The origins of resource-based view can be found in the work of Penrose (1959) who argued that companies are composed of bundles of resources that can be organized in different portfolios of goods and services. This conceptualization of organization has evolved since Penrose's work and now several authors view resources and capabilities as the primary sources for companies' competitive advantage (Barney, 1991; Grant, 1991). Resources can be viewed as those tangible and intangible specific assets that a company possesses such as manufacturing plant, equipment, brand, reputation, and intellectual capital (Teece et al., 1997), while capabilities can be viewed as the ability and skills developed by the

Table 1
A review of the environmental strategy typologies and taxonomies.

Criteria	Reference	Strategic options	Type
Technology	(Shrivastava, 1995)	Design for disassembly, manufacturing for the environment, total quality environmental management, industrial ecosystems, technology assessment	Conceptual
	(Klassen and Whybark, 1999b)	Pollution prevention, pollution control, EMS	Empirical
Environmental management orientation	(Azzone and Noci, 1998)	Unresponsive, reactive, responsive, proactive, evangelist.	Conceptual
	(Klassen and Whybark, 1999a)	Reactive to proactive: compliance, opportunistic, leadership.	Empirical
	(Angell and Klassen, 1999)	External constraint and component	Conceptual
	(Hart, 1995; Hart and Dowell, 2010)	Pollution prevention, product stewardship, clean technology, base of pyramid.	Conceptual

Table 2
Industries and sample distribution.

Industry	Number of companies
Chemical	32
Manufactured metal products	27
Electronics	20
Services	13
Textile	4
Food	3
Total	99

company to manage these resources (Barney, 1991). Because resources and capabilities may be specific for a given company and difficult to purchase or imitate, they can be considered as sources for sustainable competitive advantage.

Using the resource-based view as a theoretical background, we can argue that companies need to develop internal capabilities in order to implement ISO 14001 and keep the improvements related to environmental issues. Babakri et al. (2003) show that problems with training, EMS documentation, and operational control directly impact adoption of ISO 14001. Similarly, Liu et al. (2010) found empirical evidence from Chinese companies that learning capacity and environmental strategy orientation also impact environmental practices. In their study about green government procurement in China, Geng and Doberstein (2008) claim that companies need to improve their internal capabilities to be able to implement such practices. We also can argue that companies may adopt ISO 14001 in search of operational benefits resulting from a better and unique deployment of internal resources. For instance, companies may take advantage of mapping and standardizing their processes to learn more about potential combination of resources and capabilities. Companies may get benefits out of standardizing practices such as achieving operational efficiency after reorganizing activities and eliminating activities with no added value. In this case, the adoption of ISO 14001 may lead to the improvement in environmental practices and improvement in overall operational practices and performance.

3. Methods

We deployed quantitative and qualitative approaches in the data analysis (Bryman, 1988). First, we conducted a survey to identify the strategic groups and to propose a theoretical model based on the taxonomy found. Second, we conducted a qualitative case study to bring a detailed illustration of the Holistic group.

3.1. Sample and data

Our study targeted all Brazilian companies certified by the ISO 14001 standard. We relied on the Brazilian Institute for Metrology (INMETRO) to get information about the entire population, because the institute is responsible for conducting formal assessment of environmental and other management programs and is responsible for certifying companies adopting standard management practices in Brazil. According to data provided by INMETRO, there were 638 companies certified with ISO 14001 in 2004.

The target respondent was the operations manager in charge of implementing ISO 14001 in each company. We sent an invitation by email and made a phone call for managers in all companies in the population, asking them to participate in our study. One hundred managers accepted our invitation and participated in our survey questionnaire. We asked the respondents to choose the way they would like to receive and return the questionnaire, giving them the following options: mail, fax, phone, webpage, and email. One observation had to be discarded, though, due to missing problems, yielding a sample of 99 companies, which correspond to a 15 percent response rate. From these 99 companies, 86 also have ISO 9001 and more than 37 percent have more than 500 employees. Table 2 presents the industry distribution in the sample.

3.2. Variables

To capture the motivations of companies adopting ISO 14001 and to ensure substantive validity, we developed a questionnaire based on a comprehensive literature review. After developing the measurement items, we conducted a pretest to improve face and content validity. We submitted the questionnaire to 10 operations managers of three large manufacturing companies and to two operations management professors. We modified the measurement items according to suggestions made by the experts. The scale was originally composed of 18 measurement items using a 5-point Likert scale, in which −2 correspond to “totally disagree” and +2 “totally agree” (Table 3). We used the same scale for the items related to environmental performance and operational policies (Table 7). We conducted some descriptive statistics with all measurement items and concluded that five of them were not appropriate for further analysis given to missing and distribution

Table 3
Validity and reliability results.

Items	Factors			
	Market expectations M_MER	Environmental responsibility M_RES	Management improvement M_GES	Reward expectations M_REC
M13 Our customers expect certification	0.896			
M06 We fulfill the demands of our customers.	0.858			
M04 The market expects certification	0.783			
M02 It was a general trend in our industry.	0.689			
M08 It was our contribution to our planet’s sustainability.		0.856		
M17 We believe in doing our part to make a better world.		0.818		
M10 We wanted to do something good for the environment.		0.812		
M01 It would help our business to work more efficiently.			0.738	
M15 It could improve our productivity.			0.719	
M18 We believe that it would help us improve our processes.		0.406	0.677	
M11 We wanted a reward offered to those who get certified.				0.861
M16 An external institution motivated us to get certified.				0.783
M03 It was promised some benefit if our site got certified.				0.550
Eigenvalues	3.010	2.872	1.591	1.196
Cumulative % variance explained	23.16	45.25	57.48	66.68
Cronbach’s Alpha	0.830	0.824	0.587	0.625

Table 4
Discriminant functions and group centroids.

Discriminant constructs	Clusters		
	1 Holistics	2 External focus	3 Internal focus
M_MER market expectations	1.287	1.590	−4.779
M_RES environmental responsibility	0.795	−2.204	−0.056
M_GES management improvement	1.050	−3.704	0.647
(Constant)	−1.178	−5.255	−5.212
Cluster centroids			
Function 1	0.368	1.783	−2.574
Function 2	1.056	−2.033	−0.889

problems. For the items related to competitive priorities listed in Table 8, we used a Likert scale with five levels also, ranging from 1 (low importance) to 5 (high importance).

The motivations for ISO 14001 certification were expected to fit in four constructs: reward expectations, market expectations, environmental responsibility, and management improvements. Reward expectations are institutional theory-related motivations that show how much the company sought a certification in compliance with a requirement from the institutional context actors. Market expectations are institutional theory-related motivations, where the company behaves the way they believe the customers expect them to do. Environmental responsibility is an institutional theory-related motivation, which reveals the expectation of recognition from the broader institutional context in which the company operates. Management improvements are resource-based motivations that show the expectations that EMS would improve a plant's capabilities and competences.

4. Results

4.1. Factor analysis

To test the construct validity, we employed a principal components analysis (PCA) with Varimax rotation. We assessed reliability using Cronbach's alpha. KMO test value was 0.661, deemed acceptable, Bartlett's sphericity was statistically significant ($p < 0.000$) and correlation matrix was 0.007, a low but not null value. These results allowed us to proceed to the rest of the analysis (Hair et al., 1998). Table 3 shows factor loadings, explained variances, eigenvalues, and Cronbach's alphas for each construct. Factor loadings below 0.4 were omitted to improve the table's readability. The choice for four factors is coherent both with eigenvalue >1, cumulative percent of explained variance >60 percent, and the scree plot criteria (Hair et al., 1998). Besides the numerical criteria, the items belonging to each construct had a shared meaning. The scale validity was satisfactory, with all items loading to their expected factors (unidimensionality). The exceptions were the item M18 with factor loading near 0.4 on another factor, but with higher (0.677) loading on its own factor. The scale reliability, measured by Cronbach's alpha, was very good for the Market Expectations (M_MER) and Environmental Responsibility (M_RES) factors ($\alpha > 0.8$). The reliabilities for Management Improvement (M_GES) and Reward Expectations (M_REC) factors were close to the minimum acceptable value.

Table 5
Coefficients and correlations of the discriminant functions with the constructs.

	Coefficients of the discriminant function (unstandardized)		Construct and discriminant function correlations	
	1	2	1	2
M_MER market expectations	1.632	0.649	0.892[a]	0.428
M_RES environmental responsibility	−0.271	0.847	−0.285	0.624[a]
M_GES management improvement	−0.676	1.229	−0.093	0.351[a]
(Constant)	0.000	0.000		

[a] Largest absolute correlation between each variable and any discriminant function.

4.2. Cluster analysis

The factor scores resulting from PCA analysis were used to create the cluster solution. The cluster was obtained with the hierarchical procedure, using Ward's method and squared Euclidean distance as a measure of cases distance. Analysis of dendogram showed a four-cluster solution. A cluster validation was performed with discriminant analysis.

Before proceeding to the discriminant analysis, the Box's M was executed to assess the equality of the variance/covariance matrix assumption between the groups. The test with four clusters was significant ($p = 0.002$), showing that the variances were significantly different (Hair et al., 1998). With a new specification for the model with tree clusters, Box's M test showed no significant differences of variance/covariance matrices between groups. Therefore, a three-cluster model was the best solution compared to a four-cluster model. The three-cluster model presented a Wilks' Lambda test for reward expectations non-significant ($p = 0.113$). Thus, the three-cluster model was respecified with three constructs: market expectations, environmental responsibility, and management improvements. Again, Box's M allowed discriminant analysis execution ($p = 0.167$), and the three constructs could discriminate the groups, with a Wilks' Lambda test statistically significant ($p < 0.000$). The canonical functions could forecast the belonging to the groups: 97 percent of original cases were correctly classified, and 94.9 percent of cross validation cases were correctly classified (Hair et al., 1998).

The three-clusters solution was then validated by inputting the cluster centers obtained from the hierarchical procedure on the *k*-means algorithm (Milligan, 1980). The clusters found on the non-hierarchical procedure were very similar to the hierarchical procedure. Only five cases were out of 99 (<5%). Again, the results were submitted to the discriminant analysis. Box's M test allowed discriminant analysis execution ($p = 0.114$), and the three variables could discriminate the groups, with a Wilks' Lambda statistically significant ($p < 0.000$). The canonical functions could forecast the belonging to the groups: 99 percent of original cases were correctly classified, and 97 percent of cross validation cases were correctly classified. The fit of the discriminant functions has been improved on the taxonomy obtained from the k-means procedure. Fig. 1 shows the plot of cases according to two discriminant functions: Function 1 – which can be seen as motivations coming from the environment; and Function 2 – which can be seen as motivations coming from inside the company.

Table 4 shows the coefficients of the Fisher discriminant linear functions for each of the group centroids. The first cluster, which we termed holistic, holds the companies that sought the certification motivated simultaneously by the expectations of its markets, concerns with its responsibility with the environment and improvements in the management (efficiency). The second cluster, external-oriented, shows only concerns with expectations from the market. The third cluster, the internal-oriented, seeks certification looking for improvements on management. It is important to mention that the construct reward expectations was not significant in discriminating the groups and was excluded from additional analysis in this sub-section.

Table 6
ANOVA results for strategic groups of ISO 14001: motivations and some descriptive statistics.

ISO 14001 strategic groups				
	1 – External focus	2 – Internal focus	3 – Holistic	F statistics
Motivations	$n = 20$ Mean (S.D.)	$n = 19$ Mean (S.D.)	$n = 60$ Mean (S.D.)	
Market expectations	0.37 (0.60) [2]	−1.58 (0.42) [1,3][b]	0.40 (0.67) [2][a]	84.70*
Environmental responsibility	−0.83 (1.02) [2,3][b]	−0.11 (1.10) [1]	0.30 (0.80) [1][a]	11.32*
Management improvement	−1.30 (0.98) [2,3][b]	−0.00 (0.70) [1]	0.42 (0.69) [1][a]	37.27*
Rewards	−0.27 (0.78)	−2.25 (0.76)	0.17 (1.10)	2.29
Selected descriptive statistics				
Age of ISO 9001 (years)	8.65 (2.82)	8.80 (3.17)	8.77 (3.68)	0.10
Age of ISO 14001 (years)	4.67 (1.53)	5.20 (2.33)	5.53 (1.82)	1.47
Number of employees	1347.65 (2609.87)	873.65 (1243.01)	663.50 (833.50)	1.51

*$p < 0.05$.
The numbers in parentheses are sample standard deviations.
The number in brackets indicate the group means from which this group is significantly different at the 0.05 significance level as indicated by the Tukey's pairwise comparison test.
[a] Highest group centroid for that variable.
[b] Lowest group centroid for that variable.

Table 5, below, shows the coefficients of the discriminant functions and the correlations of the constructs with the discriminant functions, which provides stronger evidence for the interpretation above.

4.3. ANOVA

We performed analysis of variance (ANOVA) statistical tests to identify in which variables the three strategic groups that emerged from cluster analysis are different from one another. This procedure also helped to better characterize each group. We used the same variables as before to run this first group of ANOVA tests. We included again the variable reward expectations in order to test previous results and our conclusion is that this variable is not significant in distinguishing companies. Table 6 presents the results.

Finally, we perform a second group of ANOVA statistical tests with an additional set of measurement items that we obtained from our study. Our intention is to use additional variables to help in characterizing each one of these groups. Variables in this group are those that operations managers believe are important for their customers, and performance and policies related to environmental management. Tables 7 and 8 show the means, standard deviation, ANOVA results, and Tukey's pairwise test, comparing the strategic groups.

5. Discussion

5.1. Survey results

Results suggest the existence of three strategic groups. Using the theoretical lenses proposed in the literature review section of this paper, we discuss the characteristic of companies in each of these groups.

The first group is termed *Internal focus* because companies in this group are characterized by their emphasis on internal operations and resources. ANOVA results support our argument that Internal focus companies are mainly looking for improvements in their environmental management and because of the sense of responsibility of their managers. The latter corresponds to what Carroll (1979) would term ethical responsibilities. Companies in this group are neither the biggest nor the smallest in average number of employees. According to an RBV perspective, we can argue that these companies are probably trying to focus on the

Table 7
ANOVA results for strategic groups of ISO 14001: environmental performance and operational policies.

	1 – External focus	2 – Internal focus	3 – Holistic	F statistics
	$n = 20$ Mean (S.D.)	$n = 19$ Mean (S.D.)	$n = 60$ Mean (S.D.)	
Environmental performance				
- Our plant has a good economic use of our production inputs.	4.21 (0.78) [2,3][b]	4.70 (0.57) [1]	4.63 (0.58) [1]	1.51*
- We are efficient in the use of raw materials.	3.95 (0.78) [3][b]	4.50 (0.69)	4.58 (0.67) [1][a]	5.91*
Operational policies				
- We know in depth about the environmental risks related to our operations.	4.42 (0.61) [2,3][b]	4.95 (0.22)[1]	4.82 (0.54) [1]	6.04*
- Our procedures are defined for reducing the environmental risk.	4.63 (0.60) [3][b]	4.95 (0.22)	4.92 (0.42) [1]	3.58*
- We work with our suppliers for dealing with the environmental threats in our processes.	4.32 (0.67)	3.90 (1.07) [3][b]	4.53 (0.68) [1][a]	5.13
- We cooperate with R&D centers of environmental technologies.	3.05 (1.39) [3]	3.25 (1.37) [3]	4.03 (1.08) [1.2][a]	6.86*
- Our suppliers cooperate with us to minimize our environmental impact.	3.74 (0.87) [3]	3.85 (0.67) [3]	4.43 (0.61) [1,2][a]	10.42*
- We combine our efforts with other institutions for creation of non-aggressive products to the environment.	3.32 (1.20) [3]	3.40 (1.27)	4.07 (1.04) [1][a]	4.73*
- Some materials are reused in our plant.	3.79 (1.03) [3]	4.25 (1.00)	4.60 (0.74) [1][a]	6.46*
- Our processes generate toxic materials	4.11 (1.27)	3.95 (3.95)	3.98 (1.30)	0.09

*$p < 0.05$.
The numbers in parentheses are sample standard deviations.
The number in brackets indicate the group means from which this group is significantly different at the 0.05 significance level as indicated by the Tukey's pairwise comparison test.
[a] Highest group centroid for that variable.
[b] Lowest group centroid for that variable.

Table 8
ANOVA results for strategic groups of ISO 14001: competitive priorities.

ISO 14001 strategic groups				
	1 – External focus	2 – Internal focus	3 – Holistic	F statistics
To what extent are these factors are important for your customers?	$n = 20$ Mean (S.D.)	$n = 19$ Mean (S.D.)	$n = 60$ Mean (S.D.)	
Price	4.58 (0.70)	4.20 (1.24)	4.65 (0.95)	1.60
Quality	4.63 (0.68)	4.10 (1.21) [3][b]	4.73 (0.80) [2]	3.94*
Risk of environmental problems	2.84 (1.54)	1.90 (0.137) [3][b]	3.50 (1.42) [2][a]	9.59*
Risk of human health problems	3.11 (1.53) [2]	1.90 (1.80) [1,3][b]	3.50 (1.43) [2]	8.20*
Risk for user's safety	3.74 (1.59)	2.05 (1.70) [3][b]	3.85 (1.38) [2][a]	11.27*
ISO 9001	3.79 (1.36) [2]	2.55 (1.85) [1,3][b]	3.72 (1.54) [2]	4.52*
ISO 14001	3.47 (1.30) [2]	2.00 (1.38) [1,3][b]	3.60 (1.25) [2]	11.93*

*$p < 0.05$.
The numbers in parentheses are sample standard deviations.
The number in brackets indicate the group means from which this group is significantly different at the 0.05 significance level as indicated by the Tukey's pairwise comparison test.
[a] Highest group centroid for that variable.
[b] Lowest group centroid for that variable.

better use of their resources and capabilities (Grant, 1991; Hart, 1995), and move toward their performance frontier (Swink et al., 2006; Vastag, 2000). The second group is called *External focus* because it is composed of companies whose major characteristic is their focus on dealing with social pressure and institutions that regulate the environment. ANOVA results suggest that this group is driven by market expectations and rewards provided by institutions. Companies in this group are the biggest in the number of employees. Using institutional theory perspective, we argue that these companies are looking for recognition from other institutions and stakeholders by isomorphism (DiMaggio and Powell, 1983; Meyer and Rowan, 1977). As Porter and Kramer (2006) argue, larger companies are an easier target for activist groups and governments, therefore more subject to the action of external stakeholders.

The third group is called *Holistic* because it has companies whose major characteristic is placing higher value for all motivation dimensions regardless if they are internal or external. Based on these results, we can say that Holistic companies mix both internal and external focus in their environmental strategy. It is the biggest group in number of companies, but these companies are the smallest, on average, in the number of employees. We can combine both theoretical lenses here to say that these companies may be in a stage of development that allow them to exploit their internal resources in such an alignment with the environment that they are able to outperform companies in the other two groups in almost all characteristics analyzed in this study. The emergence of this group is unexpected because previous studies have not called attention to the possibility of such group of companies being motivated simultaneously by internal motivations and external pressure. Our results suggest that the Holistic group has the most advanced policies regarding environmental management and also present higher levels of environmental performance in some indicators when compared to the other two groups. This is clearly identifiable in the use of inputs and raw materials, when compared to the External focus companies' performance. We did not identify any difference regarding the three groups in external aspects such as reputation or external image. There was not any statistical difference related to toxic materials levels. Because this last aspect is related to the environmental legislation, companies must keep their emissions at certain levels to comply with the law.

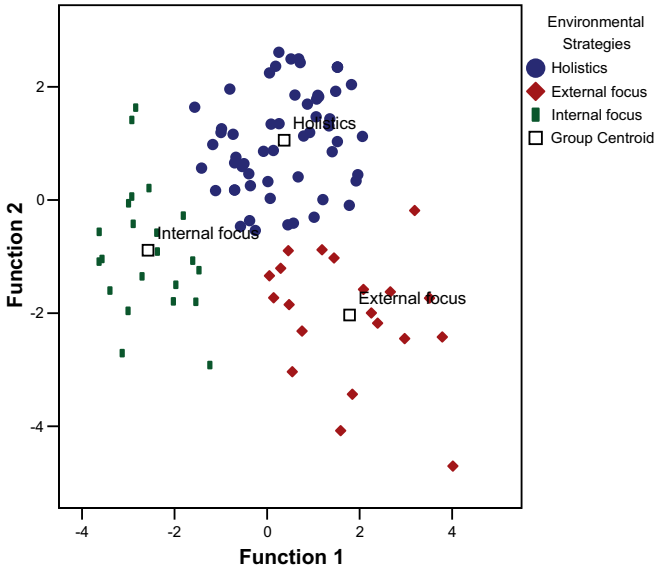

Fig. 1. Discriminant functions plot.

Besides, our results suggest that the companies in the Holistic group present a higher collaboration with suppliers in order to mitigate environmental risks and environmental impact. In addition, they have a higher level of cooperation with external R&D centers and other institutions to improve environmental performance. These practices also influence environmental performance (Gavronski et al., 2011). Therefore, the results suggest that this combination of external integration with suppliers and R&D centers leads the Holistic group to achieve a more effective use of their inputs, which consequently reduces costs and environmental impacts. This is identified in other studies on environmental management and supply chain integration (Klassen and Vachon, 2003; Vachon and Klassen, 2006) and on manufacturing strategy (Paiva et al., 2008).

No significant difference was found for the use of environmental indicators or formal documents and manuals among the three groups. This result is not surprising, since ISO 14001-based EMS requires these practices, therefore ISO 14001-certified sites, which is a common characteristic of the companies in our sample, would have similar levels of documentation and formalization, what institutional theory terms normative isomorphism (DiMaggio and Powell, 1983).

The ANOVA analysis of the factors important for customers in the perception of managers reveals the competitive priorities for the companies in the sample (Wheelwright, 1984). The Holistic group presented the highest averages among the three groups in almost all the factors. Factors related to quality and environmental issues with focus on risk presented differences statistically

significant. Only the External oriented group presented a higher value in the ISO 9001 certification importance for customers. The overall results suggest the Holistic group faces higher levels of customers exigency when compared to other groups and possibly this influences their environmental actions and policies. The External oriented group, which is formed by the largest plants, possibly has ISO 9001 as a request for supply by their buyers.

Therefore, we may consider that the competitive priorities characterize the Holistic group as having an integrated view of the environmental management, which combines external actions and internal improvements. This finding suggests a continuous process similar to a continuous improvement that is caused by external pressures (customers) and developed through external integration (suppliers, institutions and R&Ds). These results present similarities to other studies related to the relational based approach (Dyer and Nobeoka, 2000; Dyer and Singh, 1998). Fig. 2 shows a model for Holistic companies we derived both from the results and previous theory.

5.2. Illustrative example

We exemplify the Holistic group based on a company from the chemical industry. This is the industry with the highest response rate in our study. At the same time, it is one of the industries that presents high challenges regarding the environmental impact of all the processes throughout the supply chain.

The company analyzed is called Jalles Machado, located in the state of Goias, Brazil. The company produces an average of 270,000 tons of common sugar per year, 12,000 tons of which are organic. It also produces around 100,000 m^3 of ethanol. Besides this, it possesses the capacity to generate 40 MW of electricity from the sugar cane byproducts. The company was a pioneer in ISO 14001 certification and sustainable-oriented practices in this industry in Brazil. Based on our proposed model (Fig. 2), the company presents actions in all of the identified factors.

The company's clients influence the company's environmental practices. Petrobras, the Brazilian leader in the oil industry and Jalles Machado's main client of ethanol, only buys from suppliers that develop sustainable management practices. Environmental certifications like ISO 14001 are one of these practices. At the same time, final customers and international clients have shown that organic products are a market opportunity. In this way, Jalles Machado has developed new products related to the organic market, like sugar.

Regarding the integration with external R&D centers, Jalles Machado has developed projects with Centro de Tecnologia Canavieira, a Brazilian institute for research in sugar-ethanol development, for example, species of sugar cane that are better adapted to the company's location. Jalles Machado is located in Midwest Brazil, where the climate and the soil present different characteristics compared to the regions that traditionally produce sugar cane in Brazil. Also the company has projects with two universities in the state of Goias, to reduce effluents and inputs, and to improve the reuse of byproducts like the sugar cane fibers. One example is the reduction of the pesticide use in the company's crops by identifying the insect species that damage the crops, to target them with specific type and amount of pesticide.

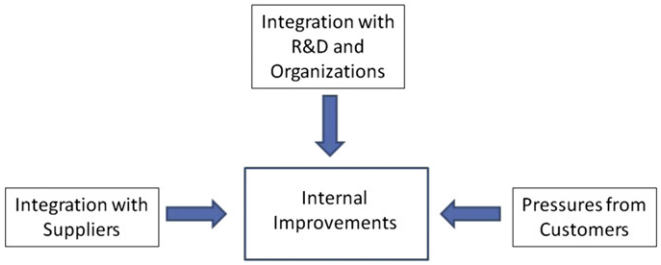

Fig. 2. Holistic environmental management in ISO 14001-certified companies.

The integration with the suppliers is oriented by new technologies development specially related to the elimination of harmful materials. The company does not require a certification of its suppliers but it evaluates them regarding operational practices that may impact negatively in the environment, such as emission. It is worth it to mention that Jalles Machado adopts a vertical integration policy. All the sugar cane used in the plant comes from its own croplands. Even with that, the company still has opportunities to improve the integration with suppliers.

These three aspects combined have allowed the company to improve internal processes. Several examples are identifiable that mitigate environmental impact of its operational activities. One with identifiable financial result is the reuse of byproducts. The company uses part of the byproducts as natural fertilizers in its crops. Around 5 percent of the byproducts are used in other processes, including electrical energy generation. All of the harvest process is mechanized and the company does not use fire to "clean"[1] the land for the next crop as traditional farmers used to do in Brazil. The company invests continually in new equipment such as gas filters to diminish emissions levels.

All of these aspects characterize a company within the Holistic group, that seeks process improvements related to environmental issues based on external integration with R&D centers, suppliers, and influenced by clients, final customers and society.

6. Conclusions

The overall results suggest that the prior motivations for ISO 14001 certification may be a good predictor of the environmental strategy a company pursues. In addition, the environmental strategy relates to the environmental performance results and operational practices in the companies. Thus, we investigated the environmental practices and results of Brazilian companies that adopted ISO 14001 in a comparative approach based on a taxonomy of environmental strategies, derived from the motivations to certification.

Initially, we reviewed prior literature to argue that Brazilian companies are motivated by either internal pressure for better use of resources or external pressure for matching social norms and obtaining recognition from stakeholders. We collected data from 99 Brazilian companies that implemented ISO 14001 and we performed cluster analysis to find strategic groups of companies and ANOVA statistical tests to assure that our findings were robust in discriminating those groups. As expected, results showed the existence of one group of companies whose focus was on performance and another group of companies whose focus was on market aspects and search for rewards. A third group of companies focused both on internal performance and on market demands. The case presented strengthens these aspects.

Our major contribution is to provide a numerical taxonomy discriminating companies according to their reasons to implement ISO 14001 and their practices and results. Previous studies

[1] Sugar cane farmers call the process of preparing the land for the next crop "cleaning." Farmers traditionally cleaned the land, before mechanization, by setting fire in the remaining canes. The fire was fast and the workers avoided snake bites, but they caused environmental problems (smoke, risk of forest wild fires, soil degradation, etc.). Advanced environmental practices in sugar cane farming include avoiding preparing the land with fire.

presented classification schemes of companies and environmental issues. Our study attempts to go a step further in the direction of a more rigorous and scientific approach to classify companies in respect with environmental issues. In doing so, we also shed light on the environmental practices and results for certified companies from an emergent country and bring them to the surface of the extent literature since most studies concentrate on exploring companies in developed countries.

Briefly, the results suggest that the Holistic group combines external and internal actions related to environmental issues. When we compare the environmental results, the main differences are related to the use of raw materials and inputs. Complementarily, differences on environmental policies are more related to integration with suppliers and cooperation with external R&D centers and other institutions. The results suggest that external integration may improve internal processes efficiency, creating a more integrated approach to environmental management. The clusters solution indicates that the Holistic group also presented the highest levels for market expectations, environmental responsibility and management improvement.

All of these aspects reinforce prior literature that has shown that external integration may lead to better internal results. Therefore, companies certified by ISO 14001 should keep other advanced management practices like supply chain integration in order to improve their environmental results.

It is worth it to mention that all the results found indicate caution. Only six industries were analyzed, therefore any generalization is limited. We only used data from one country and some regional aspects may be present in the results found. We did not evaluate companies that use other types of EMS, although that is an idea for future studies. We suggest further research on this kind of management systems. In addition, we did not evaluate plants that are not in supply chains of multinational companies. Further studies may focus on this type of company in order to complete the proposed scale and measure more properly the phenomenon. Also we suggest future studies that evaluate if different levels of pressures from the society and the media may affect the environment strategy adopted.

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