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Environmental management in Brazil: is it a completely competitive priority?

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A B S T R A C T

Current studies indicate a need to integrate environmental management with manufacturing strategy, including topics like cross-functional integration, environmental impact, and waste reduction. Nevertheless, such studies are relatively rare, existing still a need for research in specific regional contexts. At the same time, the results found are not unanimous. Due to these gaps, the objective of this article is to analyze if environmental management can be considered a new competitive priority for manufacturing enterprises located in Brazil. A cross-sectional survey was conducted with Brazilian companies certified by ISO 14001. Sixty-five valid questionnaires were analyzed through Structural Equation Modelling (SEM). The first conclusion is that environmental management presents a preventive approach in the sample analyzed, focused on eco-efficiency, what potentially do not to create a competitive advantage. This preventive approach inhibits environmental management from being regarded as a new competitive manufacturing priority, in the full sense as defined by the literature. Another important result is that environmental management, although following a preventive focus, may influence positively the four manufacturing priorities: cost, quality, flexibility and delivery.

1. Introduction

The theme of the environment is relevant to any debate about the future of industrial enterprises (Yang et al., 2010). Since the 1990s (Gupta, 1995; Sarkis and Rasheed, 1995), some researchers have drawn attention to the need for studies that integrate environmental management production strategy. Integration between environmental management and production strategy is relevant because it can lead to reduction in the impact of organizational activities on the environment (Kitazawa and Sarkis, 2000).

The involvement of companies in environmental management practices can be explained by diverse factors, outstanding among which are those for potential improvement in business performance (González-Benito and González-Benito, 2005), this being considered one of the most important research themes in the area of environmental management (Bansal and Gao, 2006). For example, there is evidence that proactivity in environmental management is positively related with the financial result (Darnall et al., 2008) and greater operational efficiency (Ahmad and Schroeder, 2003).

Besides this, companies tend to increase their market value when they announce that they are adopting environmental management systems like ISO 14001 (Jacobs et al., 2010). Wagner (2007a) concluded that integration of environmental management with other organizational functions can result in better marketing performance, an improved image, less risk and greater efficiency. Lastly, Zeng et al. (2008) reveal that environmental management and ISO 14001 are relevant to international sales growth.

However, Sarkis and Rasheed (1995) stated that the manufacturing area may face difficulty in dealing with

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environmental management, given the complexity of the theme. One of the forms of integration of environmental management into manufacturing strategy is to consider it a competitive priority in production (Jiménez and Lorente, 2001). For Jayachandran et al. (2006), there is a need for considering environmental issue in manufacturing companies with the same importance than other aspects, such as cost and quality.

However, upon analyzing recent studies on the theme (Crowe and Brennan, 2007; Darnall et al., 2008; González-Benito and González-Benito, 2005; Iraldo et al., 2009; Jiménez and Lorente, 2001; Klassen and Angell, 1998; Montabon et al., 2007; Sroufe, 2003; Vachon and Klassen, 2008; Wagner, 2007b; Yang et al., 2010), it is possible to mention that those researchers are not completely in accordance about the influence of environmental management on competitive manufacturing priorities. Analyzing their results, the influence of competitive manufacturing priorities varies among the studies, depending on the research focus. Therefore, new studies are needed in order to fill this still existing research gap. Industry- or company-specific characteristics of a country may influence the results. For instance, Klassen and Angell (1998) conclude that, when North American and German environmental contexts are compared, there are identifiable differences. Thus, the authors suggest other comparative studies analyzing different countries. For this reason, some researchers (like Klassen and Angell, 1998; Sroufe, 2003) state that more research is required regarding the effects of environmental management on manufacturing performance. Thus, a more complete view of this topic is needed.

For Nawrocka and Parker (2009), it is important to consider the specific reality of the countries when this theme is studied, the aim being to construct bases for comparison of research results. The importance of studying the relation between environmental management and competitive priorities indifferent countries was also stressed by Klassen and Angell (1998) and Darnall et al. (2008). However, the main researches on the theme portray the reality of an as yet relatively restricted set of countries, for example, in Asia (Yang et al., 2010) and Europe (González-Benito and González-Benito, 2005).

Thus, due to the need for more empirical evidence on the theme related to regions little explored by previous studies, this article investigates the following research question: May environmental management be considered a competitive manufacturing priority by companies located in Brazil?

Therefore, the main aim of this research is to analyze if the environmental criteria is to be considered as a new competitive manufacturing priority in addition to the traditional competitive priorities of companies located in Brazil.

The article is structured as follows. Section 2 presents the subjects in the following sequence: production strategy and environmental strategy (Section 2.1); environmental management, competitive priorities of manufacturing and the conceptual model, these forming the base for the development of the empirical study (Section 2.2); also, studies are presented with the specifics about environmental management in companies in Brazil, and the research hypothesis is listed (Section 2.3). Section 3 presents the methodological procedures followed. In Sections 4 and 5, the results are discussed. Finally, the concluding Section presents a synthesis of the results, limitations of the study and suggestions for further studies.

2. Theoretical review, structural model and hypothesis

2.1. Production strategy and environmental strategy

Production strategy concerns a series of decisions taken to sustain the company's business strategy or that of a business unit, potentially leading to performance gains in the business and operations areas. One of the most important components of a manufacturing strategy is its competitive priorities. These are also called competitive manufacturing dimensions or strategic dimensions (Hayes and Wheelwright, 1984; Swamidass and Newell, 1987), performance objectives (Slack et al., 1998), manufacturing mission (Schroeder et al., 1986) and competitive capabilities (Miller and Roth, 1994). These concepts are defined as key aspects for manufacturing decisions, and they indicate a strategic emphasis on developing manufacturing capabilities that may improve a company's market position (Boyer and Lewis, 2002).

Furthermore, it is clear that manufacturing strategy affects a company's environmental impact. At the same time, it is necessary to analyze the relationship between environmental management and operations management, firstly because it is fundamental to define the meaning of environmental management. Environmental management is defined as "… the organization-wide process of applying innovation to achieve sustainability, waste reduction, social responsibility, and a competitive advantage via continuous learning and development, and by embracing environmental goals and strategies that are fully integrated with the goals and strategies of the organization" (Haden et al., 2009, pp.1052). Thus, like the manufacturing area, environmental management is also related with business strategy, which can be deployed in the environmental strategy. Previous researches such as Silva et al. (2009), Abreu (2009), Jabbour (2010b), among others, considered that environmental management actions may undergo three different stages:

a) Reactive: This is the least developed stage of environmental management. The organizations positioned at this stage tend only to conform to the legislation and the advance of the environmental regulation. The focus of the environmental management system is to avoid environmental problems from occurring, the environmental management tends to wield little authority in the organizational structure, and the company does not involve itself in external activities on the environmental theme;
b) Preventive: At this stage, the organization seeks strategies to optimize the use of natural resources by means of eco-efficiency and the application of its principles, such as the 3Rs (reduce, reutilize and recycle). The environmental issue begins to be discussed by the organizational areas, the environmental management area begins to acquire greater prominence in the organizational structure and some external environmental management actions come into play;
c) Proactive: This constitutes the last stage in environmental management. At this stage, the environmental question is the fundamental element of the business strategy and for the creation of competitive advantages. It is verified that the area of environmental management is active and its actions are integrated into the other areas of the organization. The company starts to adopt technical innovations, principally to develop products with low environmental impact.

But what is the expected relation between manufacturing strategy and environmental management strategy? Although some researchers have proposed different competitive priorities – such as innovation performance (Leong et al., 1990) and service performance (Garvin, 1993) – there is strong agreement regarding four competitive priorities for manufacturing: cost, quality, flexibility and delivery (Gerwin, 1987; Hayes and Wheelwright, 1984; Hill, 1993; Hörte et al., 1987; Jiménez and Lorente, 2001; Krajewski and Ritzman, 2000; Schmenner, 1981; Schroeder, 1993; Slack et al., 1998; Stonenraker and Leong, 1994; Swamidass and Newell, 1987; Vachon and Klassen, 2006). Environmental management currently appears as an emerging and important competitive priority for manufacturing, considering companies' growing responsibility for reduction of environmental impacts related to their activities. The next Section details this relation, focusing on the relation between environmental management and the competitive production priorities.

2.2. *Influence of environmental strategy on production performance*

Since the 1990s, researchers have drawn attention to the importance of integrating manufacturing strategy and environmental aspects (Gupta, 1995; Sarkis and Rasheed, 1995). However, this link became clearer when Jiménez and Lorente (2001) established conceptual bases to relate environmental management with a new competitive manufacturing priority.

Jiménez and Lorente (2001) stated that environmental management may be considered a competitive priority for manufacturing because it satisfies two basic requirements: it is obtained within the scope of manufacturing, and it may create a competitive advantage.

The first condition for environmental management to be considered as a manufacturing competitive priority is that performance in environmental management is related to manufacturing characteristics. This aspect is considered acceptable for Operations Management (OM) literature. Some articles (Gupta, 1995; Sarkis and Rasheed, 1995) claimed that manufacturing is the locus of environmental management genesis and development in the organization. Hunt and Auster (1990) stated that manufacturing is the first functional area to embrace environmental management, and only later this discussion has disseminated to other functional areas. In a classic study, Hart (1995) stated that environmental management unfolds along a development continuum of environmental competencies in manufacturing, including pollution control and sustainable products development.

The second requirement for environmental management to be considered as a manufacturing competitive priority proposed by Jiménez and Lorente (2001) claims that environmental management can be considered a performance objective only if it allows the company to achieve a competitive advantage. The literature clearly shows that investment in environmental management leads to better business performance. This theme is one of the most important in the research about environmental management (Bansal and Gao, 2006).

Different studies show that environmental management also satisfies this second requirement. For example, Darnall et al. (2008) states that the more proactive the company's environmental management is, the better its financial performance. López-Gamero et al. (2009) also found a positive relation between environmental management practices and company performance. On the other hand, Zeng et al. (2008) states that environmental management and ISO 14001 certification are relevant to conducting international business.

Jacobs et al. (2010) show that the market value of firms tends to increase after announcements of certification by the ISO 14001 norms. González-Benito and González-Benito (2008) also affirm that the ISO 14001 system is related with a series of production management practices. Thus, it may be stated that environmental management must be viewed as an integral part of the current production practices (Yang et al., 2010). In this manner, environmental management tends to influence operational performance and business performance (Klassen and Angell, 1998; Vachon and Klassen, 2008). Therefore, the authors argue that environmental management can influence as much production performance as business performance, as suggested by Jiménez and Lorente (2001). ISO 14000 adoption may improve sustainability in supply chains (Curkovic and Sroufe, 2011), reduce solid residue (Franchetti, 2011), and improve the integration between environmental issues and organizational performance (Massoud et al., 2011). Nevertheless, (Gomez and Rodriguez, 2011) did not find a relationship between toxic emissions reduction and ISO 14000 adoption.

Thus, environmental issues related to manufacturing management should be considered as important as the traditional dimensions of manufacturing performance (Angell and Klassen, 1999), since environmental management does not present incompatibility with the other competitive manufacturing priorities (Yang et al., 2010). Indeed, environmental management may improve business performance (Jiménez and Lorente, 2001). Table 1 presents the main studies that analyze the relations between environmental management and competitive production priorities. Although only a few studies have considered all of the competitive priorities (Vachon and Klassen, 2008; Yang et al., 2010), the majority have found a synergetic relation between environmental management and operations performance.

The literature review reveals two types of research orientation. In the first group, there are those that focus on a specific competitive priority (for example, Iraldo et al., 2009; Wagner, 2007b). In the second group, researches appear with broader scope, with implications for more than one competitive priority (for example, Yang et al., 2010).

Focusing on the competitive priority of flexibility (Wagner, 2007b) results indicate that there is a positive correlation between the level of implementation of an environmental management system and environmental process innovation in manufacturing companies in Germany. Following this same line, Klassen and Angell (1998) state that flexibility in manufacturing related to innovation in products and processes, it is relevant to improve the level of environmental management in the company, but they state that the result can vary from country to country. Iraldo et al. (2009) affirm that an environmental management system can influence the performance of companies in diverse sectors, by means of technical and organizational innovations.

Montabon et al. (2007) analyzed the relation between environmental management and all the competitive production priorities. The results suggest that environmental management practices possess a positive effect on the performance of the company, in terms of cost reduction, quality (continuous improvement), innovations in products and processes, and reduction of environmental accidents, which may improve the company's delivery performance.

With focus on the relation between environmental management and all the competitive production priorities, Yang et al. (2010) analyzed environmental management as a moderating variable of the effects of the programs for continuous improvement of manufacturing and the relations with suppliers on the competitive priorities (cost, quality and delivery). With the exception of quality, the results show that environmental management potentializes the effects of advanced manufacturing programs on competitive production priorities. The authors argue that quality management has come under pressure due to international environmental norms (especially for chemical products), and this could be the reason for the non-significant relation found in such study.

Complementarily, Sroufe (2003) identified a positive relation between an environmental management system and performance in terms of cost, quality and development of new products. The cost criterion can be improved by means of waste reduction, and quality can be raised by enhancing the products, which tends to generate progressively more innovation.

Vachon and Klassen (2008) identified that the collaboration between the firm and its suppliers for the purpose of improving

Table 1
Research results relating environmental management and competitive priorities in manufacturing.

Research	Findings	Competitive priorities empirically related with environmental management			
		Cost	Quality	Flexibility	Delivery
Wagner (2007a)	Positive relation between the environmental management system and innovations in processes			✓	
Klassen and Angell (1998)	Flexibility of manufacturing is relevant to improving the level of the company's environmental management. This can vary among countries.			✓	
Montabon et al. (2007)	Environmental management practices possess a positive effect on company performance	✓	✓	✓	✓
Iraldo et al. (2009)	Systems of environmental management can influence the performance of companies in diverse sectors			✓	
Zeng et al. (2010)	Analyzed the relation between cleaner production and performance of Chinese companies	✓			
Yang et al. (2010)	Verified the effect of advanced production practices on the competitive priorities, considering environmental management as a mediating variable	✓			✓
González-Benito and González-Benito (2005)	Analyzed the relation between proactive practices of environmental management and the performance of "mass production" and "lean production" of companies in Spain		✓	✓	✓
Vachon and Klassen (2008)	Verified that the collaboration between firm and suppliers for improvement of environmental management results in operational benefits		✓	✓	✓
Sroufe (2003)	Identifies the relation between systems of environmental management and performance in terms of cost, quality and products	✓	✓	✓	

environmental management results in operational benefits, mainly those of quality, flexibility and delivery.

Thus, it can be stated that environmental management tends to influence the other competitive production criteria (based on the literature, it is possible to identify cost, quality delivery and flexibility as the most cited competitive priorities) in the following ways:

a) Cost is influenced by the reduction in raw material consumption, the seeking of eco-efficient process technologies, the replacement of raw materials with reusable and recyclable materials (Hunt and Auster, 1990);
b) Quality is strengthened and it becomes stronger with environmental management themes in quality management principles (Aboulnaga, 1998);
c) Flexibility related to innovative processes and products is enhanced through a broader range of products, a greater mix and product flexibility (Azzone et al., 1997; Porter and Linde, 1995);
d) On-time delivery when environmental accidents are not present (Hunt and Auster, 1990);

However, as Table 1 shows, these results cannot be considered as unanimous. Crowe and Brennan (2007) stated that only a minority of companies tend to incorporate the environmental issue into their competitive priorities. González-Benito and González-Benito (2005) also affirmed that environmental management practices do not produce a homogeneous effect on the competitive manufacturing priorities. They argue that only the practices related to those of environmental improvement of reverse logistics and recycling exert an influence on the competitive priorities of quality, reliability and flexibility in production volume.

Fig. 1 illustrates the conceptual model relating the environmental management construct (ξ, independent, exogenous variable) with the constructs of traditional competitive priorities and production practices (η, dependent, endogenous variable), so as to satisfy the two requisites for environmental management to indeed become a new competitive manufacturing priority, according to Jiménez and Lorente (2001).

Besides this, Klassen and Angell (1998), and Darnall et al. (2008), highlight the importance of analyzing the country context in environmental management research. In this case, some institutional aspects or cultural issues may affect environmental management, like compliance with laws and imposition of environmental fines. Some characteristics of the environmental practices in Brazilian companies are discussed in the next section (Jackson et al., 2011). Based on these studies, we propose a research hypothesis.

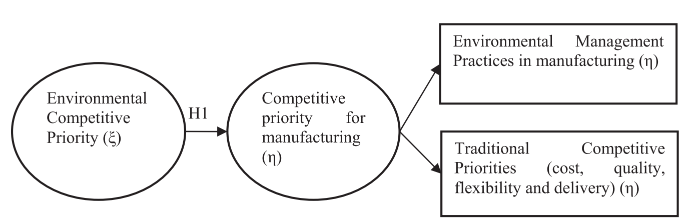

Fig. 1. The relation between environmental management and the competitive criteria to fulfil the requisites of a new competitive priority.

2.3. Characteristics of environmental management in companies in Brazil

Researches of the cross-country type (Darnall et al., 2008) have indicated a need to analyze the effects of environmental management practices on companies considering the countries' specificities. Klassen and Angell (1998) affirmed that the importance of a competitive priority for environmental management can vary according to country. For this reason, when the relation between production strategy and environmental management is analyzed, it is important to consider the characteristics of the countries. In this sense, Nawrocka and Parker (2009) also stated that it is relevant to conduct studies concerning the specificities of the countries, so that environmental management is understood within a comparative perspective.

However, upon review of some of the main studies about the relation between environmental management and production strategy (Crowe and Brennan, 2007; Darnall et al., 2008; González-Benito and González-Benito, 2005; Iraldo et al., 2009; Klassen and Angell, 1998; Montabon et al., 2007; Sroufe, 2003; Vachon and Klassen, 2008; Wagner, 2007b; Yang et al., 2010), it is identifiable that there are few studies with data from emerging economies, such as Brazil.

Regarding Brazil, it is worth noting the presence of abundant natural resources, such as the rich flora and fauna in the Amazon Rain Forest and Cerrado savannah. However, in several parts of the world, much of this natural wealth is at risk, including Brazil (for example, see Constanza, 2007). Brazil presents a robust set of environmental laws, a prerequisite for environmental accomplishment (Arrow et al., 1995). However, the big challenge faced by Brazil's government is to enforce compliance with the law. Maimon (1994) argued that environmental control and government action are key aspects to improve environmental performance in Brazilian companies. According to the author, there was a significant gap between discourse and practice in environmental management in Brazil at that time. Abreu (2009) also identified environmental regulations and compliance pressures as key factors for the increasing adoption of environmental policies by Brazilian companies. Brazil has around 2000 companies with ISO 14001 certification, according to the ISO survey (ISO, 2008). Today, Brazil is the country with the greatest quantity of ISO 14001 certifications in South America. When compared to other BRIC countries (Brazil, Russia, India and China), Brazil had more certifications than Russia, but less than India and China (data from December, 2008). The industries with the majority of certifications were automotive, petrochemical and chemical, all with international investments and high levels of environmental impact (RMAI, 2006). The company with the highest number of certifications in Brazil is Petrobras, with 41 sites certified by ISO 14001. Nearly 50% of the ISO 14001 certifications are in São Paulo State, which is the most industrialized state in Brazil (RMAI, 2006).

Researches about the strategies of environmental management in Brazilian companies suggest that advances have been obtained (Bonilla et al., 2010), but reactive and preventive strategies still predominate, based more on observance of the law, reutilization of residues and reduction in the consumption of raw materials, and less on the development of new products with high environmental performance (Jabbour, 2010a).

For example, Hojas Baenas et al. (2011) showed that some Brazilian companies, mainly SMEs, still face great difficulties in dealing with environmental management.

Jabbour and Jabbour (2009) conducted five case studies in industrial companies. The authors identified that most companies still have a strategy of preventive environmental management. According to them, the companies with more advanced environmental management practices select suppliers based on environmental criteria.

Jabbour (2010b) affirms that few companies possess proactive environmental management based on product innovation. On the other hand, in the companies studied, there is a predominant focus on the application of practices for the pollution prevention, as well as reduction, reutilization and recycling of materials. A survey with 94 Brazilian companies certified by ISO 14001 confirmed these results (Jabbour, 2010a).

Gavronski et al. (2008) analyzed the main benefits arising from the adoption of ISO 14001 in Brazilian companies. According to these authors, the benefits can be divided into internal (financial and productivity gains) and external (relation with stakeholders and greater competitiveness). Corbett et al. (2005) identified some of these benefits. On the other hand, Oliveira et al. (2010) in analyzing Brazilian companies with ISO 14001 certification, observed that the principal benefits of environmental management are related with the development of preventive activities, such as reductions in water, gas and other fuel consumption. These more recent studies confirm the findings of Maimon (1994) and Silva and Medeiros (2004) about Brazil in relation to the adoption of ISO 14001. There are still some constraints because Brazilian companies possibly still see environmental management as an additional cost and not as an competitive opportunity. Another barrier for a more proactive role of the environmental management in Brazilian companies is a existing lack of integration with other functional areas, like human resources management (Jabbour et al., 2010).

In view of the above and based on the Jimenez and Lorente (2001) premises, the following research hypothesis is proposed:

H1. Environmental management is only partially considered as a manufacturing competitive priority for companies located in Brazil.

3. Methodological procedures

This study used a cross-sectional survey (Pinsonneault and Kraemer, 1993). The first step followed an exploratory orientation, given that it was sought to understand how environmental management could be considered a new competitive priority. Thus, after this first step, there was a clearer definition of the concepts used in the research for the Structural Equation Modelling (SEM) technique.

The scales were based on prior studies by Gerwin (1987), Ward et al. (1998), and Boyer and Lewis (2002). The scale was a Likert with five points, as presented in Appendix A. A group of researchers analyzed the appropriateness and coherence of the items proposed. Redundant and ambiguous items were dropped and new ones added at this step. A pilot test was applied in a group of firms., After this step, new modifications were added to the questionnaire. After the data gathering, an exploratory factorial analysis (EFA) analyzed the constructs unidimensionality. The results of the EFA and the items used in the SEM are presented in Table 2. Therefore, based on the six latent constructs found, the variable Environmental Competitive Priority (ECP) was related with the other five constructs, resulting in five structural models (see Section 4).

The Inmetro (Brazilian Institute of Metrology, Standardization and Industrial Quality) database was used to identify ISO 14000 certified companies located in Brazil. The complete list included 710 companies. Excluding the sites within the same corporation, the total number was 474 companies.

Emails were sent to the person in charge for environmental management or manufacturing management. The first wave received 42 responses. After the second wave 23 questionnaires returned. The total sample is equal to 65 respondents, representing

Table 2
Exploratory Factor Analysis (EFA) of first factor and reliability.

Construct	Variables	Loading	Communality	MSA	Overall MSA	% of accumulated variance	α
(a) Environmental Management Practices (EMP)	V7	0.78	0.61	0.68	0.67	0.62	0.70
	V8	0.79	0.63	0.67			
	V11	0.80	0.64	0.68			
(b) Cost Competitive Priority (CCP)	V13	0.86	0.74	0.58	0.61	0.67	0.74
	V14	0.68	0.50	0.78			
	V15	0.89	0.80	0.57			
(c) Quality Competitive Priority (QCP)	V17	0.71	0.50	0.74	0.62	0.65	0.73
	V18	0.83	0.68	0.61			
	V19	0.88	0.77	0.58			
(d) Delivery Competitive Priority (DCP)	V20	0.91	0.83	0.61	0.73	0.73	0.82
	V21	0.84	0.71	0.68			
	V22	0.81	0.66	0.73			
(e) Flexibility Competitive Priority (FCP)	V23	0.77	0.59	0.88	0.78	0.68	0.88
	V25	0.87	0.76	0.77			
	V26	0.92	0.84	0.73			
	V27	0.76	0.58	0.78			
	V28	0.80	0.64	0.76			
(f) Environmental Competitive Priority (ECP)	V29	0.75	0.56	0.88	0.80	0.62	0.87
	V30	0.79	0.62	0.76			
	V31	0.78	0.61	0.80			
	V32	0.80	0.64	0.88			
	V33	0.74	0.55	0.72			
	V35	0.86	0.73	0.79			

a 13.71% of response rate. This response rate was similar to those in other Operations Management (OM) studies. Sample sizes between 60 and 70 respondents are also found in other OM studies (for example, De Toni and Nassimbeni, 2000; Ratnasingam et al., 2009; Vickery et al., 2003). Data gathering was randomly selected.

The analysis of the influence of environmental management on the four traditional competitive priorities and environmental management practices was based on nested models (two by two) as suggested by Bollen (1989) for the Structural Equation Modelling (SEM). See Fig. 2.

The respondents belong to different industrial sectors. There are 11 industries based on the National Classification of Economic Activities (CNAE) (similar to the International Standard Industrial Classification of All Economic Activities - ISIC). Table 3 shows the companies distribution according to industry and company size.

SEM was used to analyze the influence of environmental management on the four competitive priorities (cost, flexibility, quality and delivery). Structural Equation Modelling (SEM) is a statistical technique that combines elements of traditional multivariate models, such as regression analysis, factor analysis and simultaneous equation modelling. SEM is able to express relationships among several variables and, therefore, to estimate parameters and test hypotheses for several questions related to economics and behavioural sciences.

Ward et al. (1998) employed exploratory factor analysis to assess traditional competitive priorities. Since then, the use of SEM has grown considerably in the last years in OM studies. SEM allows the identification of non-observable multidimensional constructs and the analysis of structural relationships, which are not always possible by other traditional multivariate methods (Shah and Goldstein, 2006). Latent variable models may help researchers to more accurately assess each construct and explain the phenomena (Sila and Ebrahimpour, 2005). In a similar study, Gröbler and Grübner (2006) employed SEM to analyze the cumulative effects within traditional competitive priorities.

The analyses used SAS software and the CALIS procedure (Hatcher, 1994) in the following sequence: Exploratory Factor Analysis (EFA), Cronbach's α, Confirmatory Factorial Analysis (CFA), convergent and discriminant validities and SEM. The CALIS PROC is a software module for Structural Equation Model.

Before we employing EFA, the Spearman correction coefficients were analyzed, like other studies that used SEM (for example, Carr et al., 2000; Chow et al., 2008; Li et al., 2005, 2006; Sila and Ebrahimpour, 2005). The Spearman correlation was appraised for all constructs. The Spearman correlation coefficient is the most adequate for variables with ordinal scales (Hair Júnior et al., 2005), as used in this study. These correlations are presented for all the six constructs (see Appendix A).

Items from the same construct with correlations that are not statistically significant were dropped, including in this case V9 and V10. Both belonged to the Environmental Management Practices construct. The other items in the same construct presented significant correlations with at least other item from this construct as employed in this work. Thus, this correlation measurement was initially assessed for all six constructs (Appendix A).

The unidimensionality was evaluated using Exploratory Factorial Analysis (EFA) with Principal Component Analysis (PCA) and varimax rotation. The EFA was split into two parts as other studies that employed SEM (for example, Hair Júnior et al., 2005; Kaynak, 2003; Li et al., 2006). The first group was related to competitive priority constructs. The second was based on the environmental competitive priority constructs.

Six latent factors were identified: (a) Environmental Management Practices (EMP); (b) Cost Competitive Priority (CCP); (c) Quality Competitive Priority (QCP); (d) Delivery Competitive Priority (DCP); (and) Flexibility Competitive Priority (FCP); and (f) Environmental Competitive Priority (ECP). The analysis of sampling adequacy (MSA), factorial loading and communalities indicated the exclusion of items with low values (Hair Júnior et al., 2005). Table 2 shows the EFA values and the corresponding Cronbach's α.

EFA results were refined through Confirmatory Factorial Analysis (CFA), which previously, was done by use of SEM (Kline, 2005). One of the most common estimation methods for CFA is the Maximum Likelihood (ML). The ML method assumes that the data presents a normal distribution. Nevertheless, there are clear limitations when data have an abnormal distribution (Flora and Curran, 2004; Kaplan, 2000; Kline, 2005), as in this study.

The estimation method considered adequate for ordinal data is the Weighted Least Squares (WLS). Since it requires a weighting matrix as input data, this method requires a substantially large sample, otherwise the weighting matrix would be singular, precluding the use of this estimation method (Kaplan, 2000). According to Kaplan (2000) there is a limit for the number of variables, which depends on the sample size. If n is the number of companies and p the number of variables, then:

$$p < \frac{-3\sqrt{9+8n}}{2} \quad (1)$$

Hence, in the present work, the complete structural model could not be computed in a single model. Therefore, less complex models fitted to the sample size (Kaplan, 2000; Kline, 2005) were used. These models are presented in Fig. 2. Similar orientation regarding SEM use are found in other studies (for example, Vickery et al., 2003).

Refinement of the measurement models was carried out by assessing t-values, standard errors, standardized residuals, offending estimates of standardized loading, percentage of variance of endogenous variables explained by the proposed model (R^2) and the goodness-of-fit statistic (Kaplan, 2000; Kline, 2005). Those items whose results did not fit the expected values were dropped and the measurement models re-evaluated.

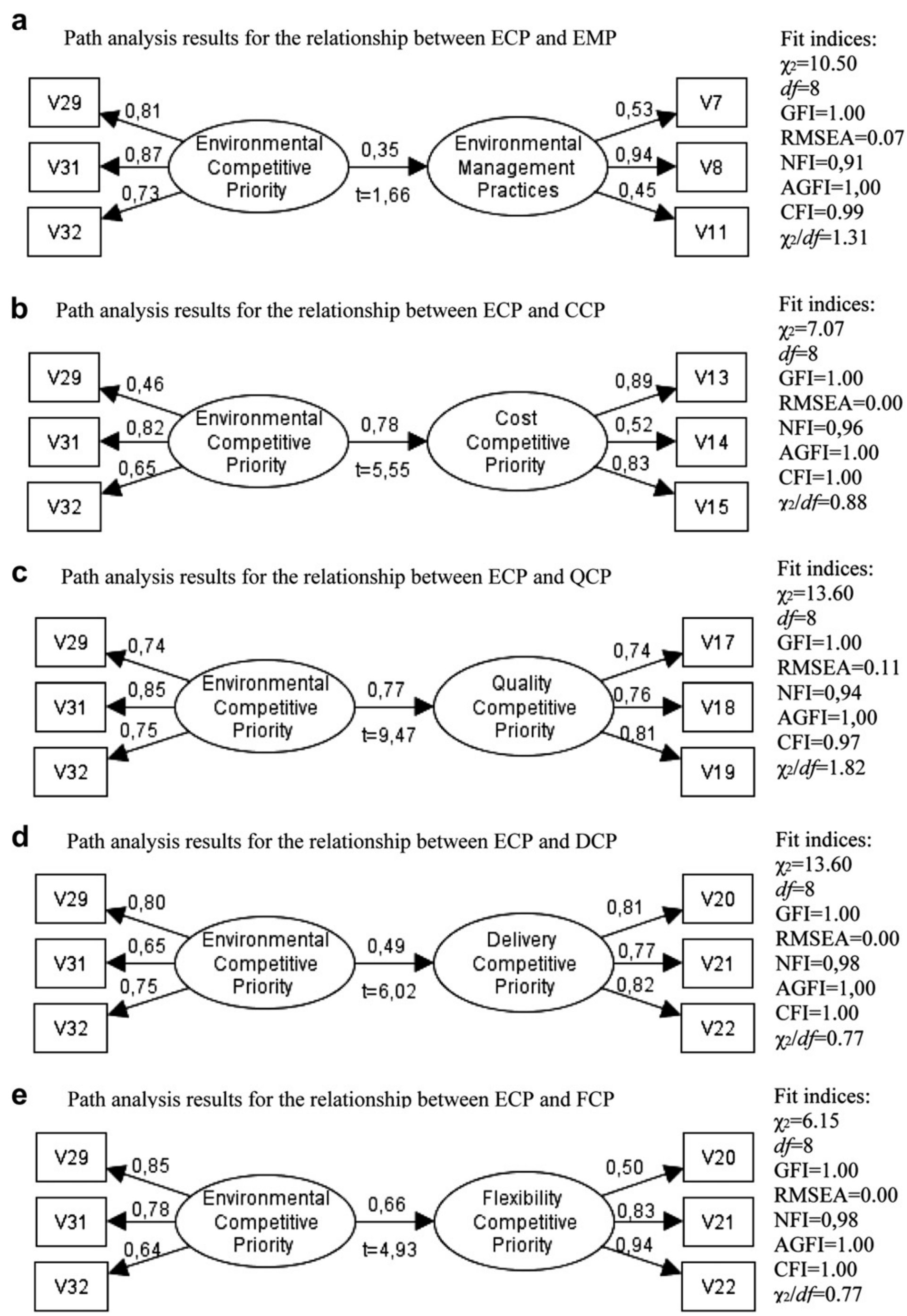

Fig. 2. Structural path analysis results for the proposed models for environmental competitive priority and traditional competitive priorities. Note: (a) $n = 63$; (b) $n = 64$; (c) $n = 65$; (d) $n = 65$; (e) $n = 65$; (f) $n = 64$; t-value for standardized load at the $t > 1.65$ ($p < 0.10$); $t > 1.96$($p < 0.05$); $t > 256$($p < 0.01$).

Table 3
Classification by industrial sector and size of studied business units.

Industrial Sector	Company Size				Total
	S	M	L	Did not reveal	
Extractive industries		1	2		3
Transformation industries	4	7	29	6	46
Electricity and gas			1	1	2
Water, sewage, waste management and decontamination activities			1		1
Construction			1		1
Commerce; automotive vehicle and motorcycle repairs	1	1			2
Transportation, storage and mail		2	1	1	4
Housing and food	1				1
Information and communication			1		1
Real estate activities		1			1
Professional, scientific and technical activities	1		2		3
Total	7	12	38	8	65

Note: S: small; M: mid-sized; L: large.

Even though the expected minimum sample size for SEM is around 100 respondents, small samples, such as 50 cases, may be valid (Hair Júnior et al., 2005). Kline (2005) stated that the ratio between the number of respondents and the total parameters should be higher than 5:1. This study presented a ratio equal to this value, (65:13) indicating model stability for the model.

It is worth highlighting that the use of Structural Equation Modelling has been increasing in the last few years in OM and environmental management studies. Nevertheless, studies with the Weighted Least Square (WLS) technique are still rare (Cunha, 2006; Gröbler and Grübner, 2006). Also, less complex models, like in this study, are more suited to this technique, which justifies the choice of WLS. This technique is also appropriate for ordinal scales, which justifies its use in this study.

4. A structural equation model of competitive priorities

Fig. 2 presents the results of the path analysis showing the relations between the environmental competitive priority construct and the five constructs identified in the EFA. Environmental competitive priority is the latent exogenous variables (ξ, independent), and the remaining constructs are the latent endogenous variables (η, dependent). Fig. 2 also shows the sample size (n) and the goodness-of-fit indices.

It is worth mentioning that the items indicated in Fig. 2 are presented by numbers (V7, V8, …,V32), and they are listed in Appendix A. Table 4 indicates the goodness-of-fit values recommended by the literature.

Table 4
Values and references of the goodness-of-fit statistics.

Goodness-of-fit statistics	Satisfactory Value	References
Goodness-of-fit index (GFI)	$\geq$0.90	Kline (2005)
Benter-Bonnetnormed fit index (NFI)	$\geq$0.90	Hair Júnior et al. (2005)
Comparative fit index (CFI)	$\geq$0.90	Hair Júnior et al. (2005)
Adjusted goodness-of-fit index (AGFI)	$\geq$0.90	Hair Júnior et al. (2005)
Normed Chi-square (χ^2/df)	$\leq$3.0	Bollen (1989)
Root mean square error of approximation (RMSEA)	<0.05 it is close; between 0.05 and 0.08 it is reasonable $\geq$ 0.10 it is poor	Kline (2005)

In the sequence, convergent and discriminant validity were evaluated. The t-values for the standardized loadings indicated that convergent validity was achieved, since all the standardized loadings of the variables yielded $t > 2.56$.

Discriminant validity was analyzed through the chi-square difference among the exogenous construct (Hatcher, 1994; Li et al., 2005). The analysis was based on a pair-wise comparison between the constrained and unconstrained models. Table 5 shows the results.

After the analysis of the five structural models it is possible to state that the five models are valid, since the path loadings are significant according to the t-values. Fig. 2 shows the results.

5. Results discussion

These results indicate that only three items of the construct Environmental Competitive Priority present relations that are statistically significant with the other competitive manufacturing priorities. They are: Replace raw materials or suppliers aimed at using raw materials that reduce the environmental impact (V29), Reduce the generation of hazardous materials (or those that cause degradation) in the environment (V31) and Reduce input consumption (water, energy, raw materials) (V32). These three items that measure the Environmental Competitive Priority (V29, V31 and V32) construct satisfied unidimensionality, convergent validity, discriminant validity and reliability. They are, therefore, statistically valid. It is important to highlight that during the data analyses and the refining of the five models, other items related to Environmental Competitive Priority construct were dripped based on the fit limits suggested by the literature.

These items (V29, V31 and V32) are associated to a preventive approach in the environmental management. They are related to endeavours to achieve greater eco-efficiency and better inputs use. Thus, the results suggest that environmental management in the sample tends to be considered within a preventive approach, as discussed in Section 2. The environmental management followed by the companies in the sample is more reactive, creating constraints to adoption of management practices that could lead to a competitive advantage.

As a consequence, the H1 Hypothesis tends to be considered valid for the sample under analysis. H1 states that Brazilian manufacturing companies tend not to consider all the competitive potential of environmental management, and, for this reason, there is a tendency to influence the traditional competitive priorities of manufacturing in a partial manner with a preventive focus.

Thus, for the sample analyzed, the environmental management cannot be regarded as a competitive priority in the full sense suggested by Jiménez and Lorente (2001). According to these authors, environmental management is identified as a new competitive priority when it influences operational performance and it is able to create a clear competitive advantage. Based on the two premises proposed by Jiménez and Lorente (2001), only the

Table 5
Assessment of discriminant validity.

	χ^2 statistic		Difference	p-value
	Unconstrained model	Constrained model		
(a) ECP ↔ EMP	10.50	50.21	39.71	<0.01
(b) ECP ↔ CCP	11.82	7.07	4.75	<0.05
(c) ECP ↔ QCP	14.52	22.16	7.64	<0.01
(d) ECP ↔ DCP	13.60	37.12	23.52	<0.01
(e) ECP ↔ FCP	6.15	22.20	16.05	<0.01

first was satisfied. Therefore, this finding is coherent with the proposed hypothesis that stated that companies located in Brazil still do not consider environmental management as a competitive priority.

In other words, the environmental management in the sample analyzed had a merely preventive approach, as shown the relation between the constructs, Environmental Competitive Priority and Environmental Management Practices (Fig. 2, "Model a"). However, the second Jiménez and Lorente (2001) requisite was not achieved, because only an environmental management with a proactive focus is able to create a competitive advantage.

The preventive approach of the environmental management in the sample becomes clearer when each of the variables of the construct Environmental Competitive Priority is analyzed. Item V29 indicates that the companies in the sample tend to replace raw materials or suppliers to improve their environmental performance. Consequently, this policy seeks to exploit the environmental competencies of suppliers instead of developing their environmental capacities (Kolk and Pinkse, 2005).

These results also suggest that these companies understand environmental management as a competitive priority for manufacturing by using the so-called 3R principles (reduce, recycle and reutilization) in the variables. The results suggest that companies seek the adoption of environmental management practices related to cleaner manufacturing principles, with environmental impact mitigation in the first stages of the manufacturing process. Nevertheless, these results are related to the prevention phase according to the evolutionary model of environmental management (for example, Silva et al., 2009).

The relation between Environmental Competitive Priority (ECP) and Environmental Management Practices (EMP) (Fig. 2, Model a) shows that environmental management influences such practices in a clear preventive approach. This orientation requires human resource management practices (V8) that make employees able to work in recycling and reutilization programs, as well as those concerning rationalization of basic inputs (Govindarajulu and Daily, 2004). Therefore, in this case, a company's focus on environmental management may be characterized as a limited competitive priority, because other advanced environmental management practices are not present.

The relationship between the Environmental Competitive Priority and the Cost Competitive Priority (Fig. 2, Model b) shows that raw materials replacement (V29) is able to generate cost reductions and to reduce the environmental impact. This is coherent with the policies related to the use of recycled materials and reduced use of basic inputs (V32).

The Environmental Competitive Priority (V29, V31 and V32) may influence the product and process quality (Fig. 2, Model c) through: (a) identification of improvements in product life cycle (V18), which at the end reduces demand pressure on product supply and consequently reduces the use of natural resources and other environmental impacts; (b) performance (V17) because high quality products require less inputs, making them more eco-efficient; and, (c) compliance (V19) with new environmental demands for the so-called green consumers.

The relationship between the Environmental Competitive Priority and Delivery Competitive Priority (Fig. 2, Model d) are justified when: (a) raw materials replacement and suppliers in search of improved environmental performance enable environmental competencies (Kolk and Pinkse, 2005); and (b) the emergence of internal environmental problems, such as the improper disposal of waste, may generate interdiction, fines and consequent delay in manufacturing plans (Hunt and Auster, 1990); and (c) use of hazardous materials may aggravate the risk in the supply chains with potential environmental disasters.

Finally, Environmental Priority may allow rapid introduction of environmentally improved products (V23), mainly through raw material or supplier (V28) replacement (Fig. 2, Model e). Although these practices are specific, they strengthen the company's capability for changing products and processes (V27), even with a preventive approach.

Even with a preventive profile, environmental management (V29, V31 and V32) and the other traditional competitive priorities of manufacturing present significant relations. The results found suggest that environmental management influences the four competitive manufacturing priorities, approximating to the results found by Montabon et al. (2007). Thus, in this study, the relation between environmental management with a preventive focus and the other competitive manufacturing priorities presented a more widespread effect than that found in previous studies (for example, Crowe and Brennan, 2007; González-Benito and González-Benito, 2005; Iraldo et al., 2009; Sroufe, 2003; Vachon and Klassen, 2008; Wagner, 2007b; Yang et al., 2010).

6. Conclusions

This research analyzed if environmental management can be considered a new competitive manufacturing priority in companies located in Brazil.

The research methodology was a survey. A group of 63 companies comprised the sample. Based on earlier researches about environmental management in Brazil, the study's hypothesis involved assessment of whether environmental management can be considered a competitive manufacturing priority for Brazilian companies, in the full sense proposed by Jimenez and Lorente (2001). The main conclusion of this study is that environmental management in the sample analyzed presents an essentially preventive approach, focused on eco-efficiency, which does not lead to a competitive advantage based on the environmental performance. Thus, due to this predominantly preventive approach, the environmental management of these companies cannot be considered as a competitive manufacturing priority as proposed by Jimenez and Lorente (2001).

Another relevant result is that environmental management, albeit within a preventive approach, influenced the four competitive manufacturing priorities: cost, quality, flexibility and delivery. Few studies like Montabon et al. (2007) explored this issue and found similar results. Other studies on this topic have concluded that environmental management is more related to a specific manufacturing priorities.

Some initial conclusions emerge from this study. The results suggest that environmental management needs to be integrated to other functional areas. The positive relation between environmental management and human resources policies (V8) is clear in the results. Possibly, innovative practices related to environmental management, such as the inclusion of this issue in product development, may improve environmental management proactiveness. Moreover, collaborative activities along the supply chain may lead to product adaptation oriented by environmental issues, changes in processes, reverse logistic planning and remanufacturing. Further studies may explore in depth the relationship between collaborative practices in the supply chain and environmental management.

The results found are potentially useful for scholars and practitioners. For scholars, this research adds new results to the debate about the relation between environmental management and manufacturing management. For practitioners, especially for those in Brazilian context or in markets with similar characteristics, the results suggest that there is still a lack in adoption of proactive environmental management practices and this aspect may be a constraint for competitive advantage creation. These findings also indicate that decisions about environmental management should consider all the competitive manufacturing priorities. This process tends to become more intense with continuous improvement processes and with a proactive orientation of environmental management. In this light, environmental management may really be considered a competitive priority of the manufacturing companies located in Brazil.

These results should be considered within the limitations of this study. It was focused only on the manufacturing sector, disregarding the service sector. The research sample is statistically satisfactory, but, even so, it is relatively small. Besides this, the conclusions must be considered with extreme caution for companies non located in Brazil. In this sense, the Brazilian context for environmental issues is completely distinct when compared to other industrialized, and even emerging, economies, including legislation compliance, natural resources availability, and high involvement of low income population in recycling activities. Regarding the first aspect, there are still challenges because, at the same time that the legislation is comprehensive, the territory is wide and some regions are still isolated, such as the Amazon. Also, there are national regional differences regarding economic development (the South-East is wealthier than other geographical regions), which leads to differences in legislation compliance, especially in the less developed regions. Also, if the low income earners participate actively in recycling activities, the same does not occur among the higher income group. Thus, as Jackson et al. (2011) stated, national or regional culture may influence organizational environmental culture in aspects, like adoption of environmental management as an organizational routine.

These limitations create opportunities for the development of new studies in this topic. The first suggestion would be to develop the same type of analysis for services companies, analyzing the relation between environmental management and operations management. Another suggestion would be the proposition of a conceptual model for Brazilian manufacturing companies to achieve a proactive environmental management. This model could be based on best practices in environmental management related to emerging countries. The final suggestion concerns the need for broader analyses, with larger or cross-country samples. These studies also may use the same scales allowing results comparison.

Appendix A. Questionnaire

Company Name:
Activity Sector:
Average monthly earnings over the past 12 months.
()up to R$ 100 thousand.
()over R$ 3 million and up to R$ 5 million.
()over R$ 100 thousand and up to R$ 875 thousand.
()over R$ 5 million and up to R$ 10 million.
()over R$ 875 thousand and up to R$ 3 million.
()over R$ 10 million.

A. Environmental Management Practices Construct (EMP)

Please, indicate a number from 1 to 5 for each statement, according to the degree of occurrence at your production unit over the past two years, where 1 = never, 2 = rarely, 3 = sometimes, 4 = frequently and 5 = always.

V7 Environmental performance criteria are considered in the new product/service development process.

V11 Environmental criteria are systematically planned in production capacity expansion and new investments in production decisions.

V12* Environmental issues are considered strategic by the company and seen as a source that generates company growth and sustainability opportunities.

For the following questions, the response scale is: 1 = not implemented, 2 = beginning to implement, 3 = partially implemented, 4 = considerably implemented and 5 = totally implemented.

V8 Human resource management practices are integrated to business environmental management objectives.

V9* Environmental performance audits are performed with suppliers.

For the following question, the response scale is: 1 = no investment, 2 = little investment, 3 = moderate investment, 4 = more than moderate investment and 5 = intensive investment.

V10* Over the past two years, there has been investment in environmentally appropriate equipment.

B. Cost Competitive Priority Construct (CCP)

Below are some priorities that production units yearn to achieve in order to maintain or increase competitiveness. Please indicate the degree of importance your production unit attributes to each statement below, where 1 = no importance, 2 = little importance, 3 = moderate importance, 4 = much importance and 5 = extreme importance.

V13 Reduce inventory cost.
V14 Increase capacity utilization.
V15 Reduce production cost.
V16* Increase work productivity.

C. Quality Competitive Priority Construct (QCP)

V17 Offer high-performance, quality products/services.
V18 Offer products/services with high durability (long life).
V19 Improve product/service compliance following project specifications.

D. Delivery Competitive Priority Construct (DCP)

V20 Provide fast delivery.
V21 Deliver according to scheduled deadlines.
V22 Reduce product/service lead time.

E. Flexibility Competitive Priority Construct (FCP)

V23 Introduce new products/services quickly.
V24* Be able to adjust production capacity in a short time.
V25* Offer products/services with a variety of characteristics and options (mix).
V26* Offer different product/service lines.
V27 Be able to alter the product/service process (script).
V28 Be able to alter materials to adapt product/service component variations.

F. Environmental Competitive Priority Construct (ECP)

V29 Replace raw materials or suppliers aimed at using raw materials that reduce the environmental impact.
V30* Encourage the internal and external reutilization and recycling of waste.
V31 Reduce the generation of hazardous materials (or those that cause degradation) in the environment.
V32 Reduce input consumption (water, energy, raw materials, etc.)

V33* Develop measures used in the technological base of the manufacturing process that aim at reducing environmental impact.

V34* Develop new environmentally appropriate products/ services.

V35* Reduce waste in the production process.

Note: The variables of the EMP construct were adapted from the study by Angell and Klassen (1999). The CCP, QCP, DCP, FCP and ECP construct variables were adapted from the study by Gerwin (1987), Ward et al. (1998), Boyer and Lewis (2002), Rao et al. (2006), Florida (1996). The variables marked with an asterisk were eliminated in the EFA refinement process and the measuring model.

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