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Environmental human resource management and competitive advantage

Eva Carmona-Moreno, José Céspedes-Lorente and Javier Martinez-del-Rio

Dirección y Gestión de Empresas, Universidad de Almeria, Almeria, España

Abstract

Purpose – The purpose of this paper is to analyze the moderating effect of environmental human resource management on the relationship between firms' environmental management practices and competitive advantages of cost and differentiation.

Design/methodology/approach – CEOs of Spanish chemical firms were asked to respond to a questionnaire containing the measures of the study variables. The final sample consists of 94 firms and the hypotheses were tested using partial least square methodology.

Findings – Empirical evidence showed that companies with a high level of human resource environmental practices can benefit from the advantages in costs and differentiation derived from the implementation of pollution prevention technologies.

Originality/value – From a theoretical standpoint, the paper discusses the moderating role of environmental human resource management practices in the relationship between pollution prevention technologies and economic performance. Empirically, it provides evidence of the role of human resource management practices and proactive environmental management practices in supporting competitive advantages of cost and differentiation.

Keywords Spain, Chemical industries, Pollution, Competitive advantage, Environmental management, Environmental human resource management

Paper type Research paper

Resumen

El propósito – El objetivo de este artículo es analizar el efecto moderador de la gestión medioambiental de recursos humanos en la relación entre las prácticas avanzadas de gestión ambiental de las empresas y las ventajas competitivas en costes y diferenciación.

La metodología – Se solicitó a los directores generales de empresas españolas del sector químico que cumplimentaran un cuestionario con medidas de las variables del estudio. La muestra final estaba constituida por 94 empresas. Las hipótesis fueron contrastadas utilizando la metodología de Mínimos Cuadrados Parciales (PLS).

Los resultados – La evidencia empírica encontrada muestra que las empresas que emplean en mayor medida prácticas medioambientales de gestión de recursos humanos pueden beneficiarse de ventajas competitivas en costes y diferenciación, derivadas de la implantación de tecnologías de prevención de la contaminación.

La originalidad/el valor – Desde un punto de vista teórico, el artículo analiza el papel moderador de las prácticas medioambientales de gestión de recursos humanos en la relación entre las tecnologías de prevención de la contaminación y el rendimiento económico. Desde el punto de vista empírico, se proporciona evidencia sobre el papel de las prácticas de recursos humanos y la gestión ambiental proactiva en la consecución de ventajas competitivas en costes y diferenciación.

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Palabras clave Gestión ambiental, ventajas competitivas, gestión medioambiental de los recursos humanos

Tipo de artículo Artículo de investigación

Resumo

Propósito/objectivo – O objectivo do artigo é analisar o efeito moderador da gestão de recursos humanos ambiental sobre a relação entre as práticas de gestão ambiental das empresas e as vantagens competitivas de custo e diferenciação.

Metodologia – CEOs de empresas químicas espanholas foram convidados a responder a um questionário contendo as medidas das variáveis do estudo. A amostra final é composta por 94 empresas. As hipóteses foram testadas usando a metodologia Mínimos Quadrados Parciais.

Resultados – A evidência empírica mostra que as empresas com um elevado nível de práticas de recursos humanos ambientais podem beneficiar de vantagens em termos de custos e diferenciação derivadas da implementação de tecnologias de prevenção da poluição.

Originalidade/valor – Dum ponto de vista teórico, o artigo discute o papel moderador de práticas de gestão dos recursos humanos ambientais na relação entre tecnologias de prevenção da poluição e desempenho económico. Empiricamente, fornece suporte ao papel das práticas de gestão de recursos humanos e práticas de gestão ambiental proativas na obtenção de vantagens competitivas de custo e diferenciação.

Palavras-chave Gestão ambiental, Vantagens competitivas, Gestão ambiental de recursos humanos

Tipo de artigo Artigo de investigação

Introduction

The analysis of the relationship between the adoption of environmental practices and corporate performance constitutes a central stream of research in the literature on environmental management (Cohen *et al.*, 1995). Studies that analyse environmental practices from the resource-based view (RBV) suggest that environmental strategies can lead to the creation and development of valuable capabilities which are both rare and difficult to imitate. This focus suggests that companies that adopt proactive or advanced environmental strategies will obtain a sustainable competitive advantage (Hart, 1995; Russo and Fouts, 1997; Sharma and Vredenburg, 1998).

Although the role of green technologies in the creation of strategic capabilities and the possibility that they might lead to the acquisition of competitive advantages have been dealt with in several studies (Christmann, 2000; Shrivastava, 1995b), some questions require further research. First, some studies have pointed out that the motivation and involvement of the firm's employees is a fundamental prerequisite for the successful implementation of green technologies (James, 1996; Darnall *et al.*, 2008). In this context, the development of human resource management practices constitutes a strategic capability to sustain competitive advantages linked to environmental management. Despite this wealth of research, few studies have analysed the relationship between specific practices that encourage the employees' involvement, "green" human resource management practices and corporate environmental performance (Jabbour and Santos, 2008b). The research question we submit is timely; only those companies with an advanced personnel management in environmental issues will be able to benefit from the cost and differentiation advantages associated with advanced techniques of environmental management (e.g. pollution prevention). Second, empirical studies analysing the benefits of implementing advanced practices of environmental management have focused on the improvement of the firm's overall performance or on savings on costs (Christmann, 2000).

Therefore, there is no conclusive research about the extent to which different environmental management practices (e.g. pollution prevention and green human resource management practices) may be related in a different way to costs and differentiation advantages (Shrivastava, 1995a).

Consequently, this study aims to enhance knowledge about the relationship between environmental practices and performance and proposes that green human resource management policies moderate the relationship between pollution prevention practices and environmental competitiveness (e.g. cost and differentiation advantages). This analysis draws on the RBV and suggests that pollution prevention technologies and green human resource management practices are complementary strategic assets (Teece, 1986). Along these lines, it highlights the importance of human resource management practices in firms' strategies for which sustainability is a high priority (Jabbour and Santos, 2008b) and this has theoretical (e.g. to enhance knowledge about whether proactive environmental practices improve business performance) and practical implications (e.g. organisational actions leading environmental sustainability).

The supporting evidence of this study enhances knowledge about the relationship between green human resource management practices and performance (Jabbour and Santos, 2008a). In this respect, our supporting data draw on a sample of Spanish chemical firms.

The RBV and the natural environment

The RBV of the firm explains differences in companies' profitability. This perspective maintains that these are the reflection of the differences in resources and capabilities of competing companies (Wernerfelt, 1984; Grant, 1991; Barney, 1991). Some research draws on the RBV to examine environmental strategies (Christmann, 2000; Judge and Douglas, 1998; Klassen and Whybark, 1999; Marcus and Geffen, 1998; Maxwell *et al.*, 1997; Rugman and Verbeke, 1998; Russo and Fouts, 1997; Sharma and Vredenburg, 1998). Shrivastava (1995b) argues that environmental technologies (e.g. design for recycling, total environmental quality, industrial ecosystems) constitute potential strategic resources because they provide firms with unique advantages along the value chain. Therefore, the RBV suggests that environmental performance and economic performance are related, as one or more of the environmental resources and strategic capabilities lead to multiple competitive advantages (Klassen and Whybark, 1999). Thus, proactive environmental policies and environmental performance have been linked to improved economic performance (Klassen and McLaughlin, 1996; Russo and Fouts, 1997; Judge and Douglas, 1998).

The relationship between environmental management practices and competitive advantage

Pollution prevention is an advanced environmental management policy that focuses on the elimination of waste at the source, by modifying production processes and producing more environmentally friendly goods and services (Hart, 1995). Prior research on pollution prevention technologies suggests a relationship with the development of resources and organisational capabilities. Russo and Fouts (1997) show how environmental prevention policies exert a positive influence on capabilities related to physical assets and technology, human resources and intangible assets. In the first case, pollution prevention brings about redesigning the production process

and/or the services offered by the company. Such redesign involves the acquisition and implementation of new technologies; physical assets constitute a source of competitive advantage inasmuch as they enable firms to outperform the income generation of their competitors. If the physical assets are acquired on the market, it follows that they are also available to the competitors. Nevertheless, if the physical assets are developed in such a way that they allow the firm to capitalise and improve on their internal methods of waste reduction and saving of resources, the advantages are less evident; firms stressing prevention technologies tend to create internal and idiosyncratic routines and the resulting capabilities feature the notion of causal ambiguity (Russo and Fouts, 1997, p. 538). Causal ambiguity, which is an important underlying factor of inimitability, occurs when the source from which a firm's competitive advantage stems is unknown (Peteraf, 1993).

When these routines are spread across the firm, organisational knowledge on prevention technologies becomes more extensive and this in turn reduces the likelihood of costs associated with environmental risks (Shrivastava, 1995a) and may contribute towards the reduction of manufacturing costs (Christmann, 2000) and the improvement of firm's reputation. On the other hand, the use of clean technologies adds complexity to both the manufacturing process and the provision of services. Furthermore, this requires additional skills on the part of the employees at all corporate levels (Groenwegen and Vergragt, 1991). Consequently, prevention is a more comprehensive and socially complex process than pollution control, requiring the employees' involvement, co-ordination between the different corporate levels and departments and a more participative management style. The process of developing a pollution prevention policy helps to strengthen the company's resources leading to organisational commitment and learning, integrating the different functions, skills and participation of the employees. Once again these resources may result in a competitive advantage associated with costs, as learning reduces the average unit cost. At the same time, they can be a source of differentiation as there exists a demand for personnel's specific knowledge of the products, which is encouraged by commitment, involvement and learning.

Finally, Russo and Fouts (1997) suggest two intangible factors that may improve financial performance. The reputation for leadership in environmental matters constitutes the first factor; pollution prevention practices may increase organisational sales, especially among customers with environmental sensitiveness. Likewise, as the company implements its environmental policy it may also build its reputation as a source of competitive advantages. A reputation for being environmentally sound may draw on a reputation for quality and once obtained it becomes a resource which is difficult to imitate. Prevention helps to avoid accidents and dumping, as it avoids the generation of waste and allows the company to project itself as the solution to the community's environmental problems.

The above arguments imply that pollution prevention practices applied by the company may constitute strategic capabilities in themselves or as a consequence of the development of other related capabilities. Thus, we hypothesize:

H1. Companies using pollution prevention technologies most intensely will achieve greater cost and differentiation advantages from environmental strategies than their counterparts that do not do this.

Environmental management of human resources

Teece (1986) introduced the notion of complementary assets, that is, resources or capabilities needed to achieve the benefits associated with a given strategy, technology or innovation. Teece suggested that successful commercialisation of an innovation requires that know-how is used in conjunction with other firms' manufacturing and distribution resources or assets. For instance, a new product would be of no value if these complementary assets did not exist. Along the same lines, the literature on the RBV has examined how the new applications and combinations of resources lead to competitive advantages (Grant, 1996; Kogut and Zander, 1992). The existence of complementary assets which are hard to imitate may contribute to the sustainability of the competitive advantage inasmuch as competitors do not have access to them. In this case, complementary assets are resources enhancing a firm's competitiveness as consequence of the implementation of pollution prevention technologies (Christmann, 2000, p. 666). Many companies do not have full access to the potentials of pollution prevention technologies due to organisational obstacles such as the lack of information, poor integration of processes, insufficient internal resources (Tarricone, 1996) and unsupportive organisational cultures towards the implementation of employees' ideas (Hanna *et al.*, 2000). The lack of complementary resources may also explain why some companies fail to achieve the potential benefits associated with pollution prevention.

Several studies suggest employees' involvement is crucial to develop an integrated environmental policy (Shrivastava, 1995b; Hart, 1995; Russo and Fouts, 1997; Hoffman, 2000). In particular, Daily and Huang (2001) argue that superior environmental performance requires supporting human resource practices. However, little is known about the organisational dynamics related to the contributions from human resource management to environmental management (Rothenberg, 2003).

From an RBV perspective, human resources are strategic resources to the firm (Wright *et al.*, 1994; Kamoche, 1996). According to Mueller (1996), human resources must work in conjunction with other physical, technological and organisational resources to bring about a difficult to imitate co-specialisation and the development of sustainable competitive advantages. In this respect, pollution prevention technologies cannot generate a competitive advantage if a firm's human resources are not committed to their implementation. Human resource practices can contribute to the development of routines related to environmental learning among corporate members (Bringer and Benforado, 1994; Guimaraes and Liska, 1995) in such a way that sustainable competitive advantages can be achieved. On the other hand, the implementation of pollution prevention technologies just constitutes a step within a wider process of adopting sustainable strategies (Hoffman, 2000, pp. 167-82). Human resource management systems play a fundamental role in facilitating this change by developing an appropriate rewards system, basing the selection of employees on the right criteria and by promoting the interaction of employees with both internal and external stakeholders.

Suitable management of environmental knowledge is crucial to attain a competitive advantage. Employees store a substantial part of an organisation's specific knowledge (Grant, 1996; Kamoche and Mueller, 1998). By transferring and integrating this specific knowledge into organisational routines, a collective body of knowledge can be created which is both difficult to imitate and allows a competitive advantage to be sustained (Crossan *et al.*, 1999). A logical extension of this argument is that the way in which human resources are managed has a considerable bearing on the organisation's learning

capability (McGill *et al.*, 1992; Barrie and Pace, 1997; Kamoche and Mueller, 1998). These human resource strategies enhance the staff's capabilities and skills, while at the same time keeping them up to date (Freidman, 1991). This allows a superior organisational learning capability as well as sustainable competitive advantages (Leonard-Barton, 1992; Nonaka and Takeuchi, 1995). Human resource practices, therefore, enhance the creation of capabilities related to learning by the implementation of pollution prevention technologies. As noted by Rothenberg (2003), employees are the main experts in the way the environmental dimension can be included in the most fundamental organisational activities, including not only environmental management systems but also the development of new products and processes or changes in existing products. "Environmental knowledge", which is stored by the company's human resources and developed through environmental human resource management practices, forms the foundation of environmentally appropriate innovations (Jabbour and Santos, 2008b).

There is a dearth of empirical evidence addressing the moderating role of human resource management practices in the relationship between pollution prevention techniques and competitive advantages (Jabbour and Santos, 2008b). Egri and Hornal (2002) indicate extant knowledge in this area comes from case studies (Dechant and Altman, 1994; Lawrence and Morell, 1995; Milliman and Clair, 1996; Shrivastava, 1996). Moreover, most empirical studies have only included a limited set of human resource environmental management practices. At best, this analysis has been on a secondary role. In a sample of 37 manufacturing companies with over 250 employees in Ontario (Canada), Egri and Hornal (2002) showed support for the following notions:

- human resource environmental management practices are not thoroughly widespread across companies and only few top managers consider that they are affected by them;
- environmental training is the most widespread practice, especially for employees and managers;
- environmental proactivity and the implementation of human resource environmental management practices are positively related with perceived improvement of organisational performance; and
- contextual factors of the organisation such as size, the existence of environmental management units and the degree of unionisation are related to environmental proactivity and the perceived benefits of environmental management.

Several studies found that environmental training and employees' motivation and participation constitute key factors to explain success in the implementation of environmental certification systems (e.g. ISO 14001) as well as the improvement of environmental performance (Brío *et al.*, 2007; Wee and Quazi, 2005; Zutshi and Sohal, 2004; Ramus, 2002; Jabbour and Santos, 2008b).

As noted above, several case studies suggest the relevance of human resource practices on environmental sustainability. For instance, Hanna *et al.* (2000) point out that many environmental improvements are the result of projects carried out by groups of employees created within initiatives aimed at staff involvement. Furthermore, extant research has shown that successful companies at implementing programmes to reduce emissions of toxic substances are those which involve their employees in pollution prevention activities (Bunge *et al.*, 1995). Pollution prevention initiatives are not

necessarily linked to technology but should be rather focused on the organisation itself in order to build responsibility and internal visibility. Aspects such as an inadequate compensation and rewards system, the hierarchy of power and difficulties to get access to relevant information can all impede the personnel's involvement and reduce the chances of success of "green" technology. Jabbour *et al.* (2008, p. 1925) analysed four Brazilian companies and found "that the interactions between human resource practices and environmental management are not only theoretically, but also practically scarce in the organizational context". Nevertheless, they showed that one firm which considered the environmental dimension as an important factor for its competitiveness, used human resource practices which were not applied by the other companies (e.g. training, teamwork, definition and appraisal of environmental goals and non-financial rewarding for high performance environmental projects).

From the arguments shown above, we hypothesize:

H2. The level of a firm's use of environmental human resource management practices will moderate the relationship between its use of pollution prevention technologies and the cost and differentiation advantages it gains from environmental strategies.

Methods

Sample and questionnaire

This study examines the effect of adopting pollution prevention measures on the creation of competitive advantages of costs and differentiation in the Spanish chemical industry. This target sector has been chosen for several reasons. In many industrialised countries the chemical industry is subject to the most stringent regulations regarding waste emissions. Furthermore, the costs of complying with environmental regulations and adopting pollution prevention measures are very high (Hoffman, 2000). Finally, firms in the chemical sector may draw on their environmental policies to build differentiation opportunities *vis-à-vis* their competitors.

In order to obtain a representative sample, an initial selection was made including the Spanish companies with CNAE code 24 (chemical sector) employing a minimum staff of 50 in 2,000 (417 firms). The final sample consists of 94 firms which returned the questionnaire in a period of two years (2003-2004), representing a response ratio of 22.5 percent. Although relatively low, this percentage is similar to those obtained for mailed surveys to top executives of firms (Christmann, 2000).

The representativeness of the sample obtained was assessed by comparing some of the available variables of all the companies in the sector (total assets, number of employees, profit in 2003, equity) with those in our sample. No significant differences were found for any of the variables considered. Nonetheless, we cannot reject the assumption that the most environmentally aware companies were those which answered the questionnaire, since there are no secondary bases available on which to contrast this type of information.

Variables and measures

The items used in this study were adopted from the literature review. In two cases, previously validated scales were used (environmental management and cost advantage), while for the two other scales new items were developed (environmental human resource

and differentiation advantage). A factor analysis with varimax rotation, considering all items (four scales), revealed the unidimensionality of the constructs.

Environmental management: pollution prevention. Pollution prevention implies the adaptation of both the product and the process (Klassen and Whybark, 1999). In the former case this requires fundamental modifications in the product design to include all the stages of its production, use, storage and elimination or reuse. In the latter case important modifications are made in the production process, including the acquisition of materials, the production system and the distribution process. In most cases, it requires innovating in process technologies and developing new or improved products. The application of pollution prevention measures should lead to a reduction of the negative impact of both its use and its manufacturing process. In order to measure pollution prevention, we considered five items, which were drawn from Christmann (2000). These scales are particularly appropriate as they specifically refer to the use of different pollution prevention technologies and the innovation of such technologies in the chemical industry. Interviews were held with experts in this field before drawing up the final list of items and these led to one inappropriate item being omitted. Thus, the final list consisted of four items. Through a 7-point Likert scale, managers rated the level of implementation of each pollution prevention practice in their organisations, relative to other firms in the chemical industry. The factor analysis revealed the unidimensionality of the environmental management construct, including items related to the use of pollution prevention technologies and innovation in pollution prevention technologies and products.

Environmental human resource management. Extant research identified some human resource practices related to the effective implementation of environmentally friendly practices (Hoffman, 2000; Egri and Hornal, 2002; Jabbour and Santos, 2008a). In order to measure the complementary capabilities derived from the system of human resources, we used six questions, which were commonly used by prior research in this area; such questions assessed the extent to which a firm:

(1) has a permanent programme of environmental training for its employees;

(2) uses a system which encourages initiatives on environmental improvement and rewards the best among them;

(3) recruits and selects staff with more experience in environmental issues than its competitors;

(4) sets environmental goals for its employees;

(5) establishes a rewards system depending on the employees' involvement in environmental issues; and

(6) has staff with greater acquired knowledge of environmental issues than its competitors.

These five items were rated on a 7-point Likert scale ranging from 1, "strongly disagree" to 7, "strongly agree".

Competitive advantage in cost. We measure the dependent variable on the basis of a subjective evaluation of the cost advantages arising from the firm's environmental strategy. We adapted the 7-point Likert scale developed by Christmann (2000). In this manner, we included three questions to assess the extent to which the company has lower costs than its competitors as a result of complying with environmental legislation, using resources more efficiently or having a better overall position regarding costs.

Competitive advantage in differentiation. We have chosen a subjective measure to evaluate the competitive advantage in differentiation that arises from a firm's environmental strategy. We considered the main benefits associated to an environmental differentiation strategy in terms of the firm's environmental reputation, increased sales or environmental innovation (Shrivastava, 1995a; Karagozoglu and Lindell, 2000). We used five items to assess the extent to which the company's ecological image is better (or worse) than that of its main competitors (all items were rated on a 7-point Likert scale): whether the environmental values of the firm's products allow it to increase sales; whether the company manufactures products which are more environment-friendly than its main competitors' products; whether its production processes contaminate less; and whether the company's marketing of its products highlights their ecological values.

Control variables. As control variables we have included the firms' size (number of employees), past financial performance (three year average of ROA), capital structure (debt ratio) and whether the company is a subsidiary of a larger corporation (a dummy variable taking the value 1 if this is indeed the case). The information on these variables was obtained from the Spanish SABI database. These controls may be related to the level of environmental strategy proactivity (Alvarez *et al.*, 2001).

Analysis

The data were analysed in two separate but sequentially related stages of analysis by structural equation modeling, using partial least square (PLS). First, the measurement model was tested by performing a validity and reliability analysis on each of the measures. Second, the structural model was tested by estimating the paths between the variables in the model, determining their significance as well as the predictive ability of the model. Being a components-based structural equations modeling technique, PLS is similar to regression, but it simultaneously models the structural paths (i.e. theoretical relationships among latent variables) and measurement paths (i.e. relationships between a latent variable and its indicators). Rather than assume equal weights for all indicators of a scale, the PLS algorithm allows each indicator to vary in how much it contributes to the composite score of the latent variable. Thus, indicators with weaker relationships to related indicators and the latent construct are given lower weightings. In this sense, PLS is preferable to techniques such as regression which assume error free measurement (Chin *et al.*, 2003). As a consequence of using an iterative algorithm consisting of a series of ordinary least squares analyses, identification is not a problem for recursive (i.e. one way path) models, nor does it presume any distributional form for measured variables. Furthermore, sample size can be smaller than for covariance-based procedures (e.g. LISREL).

To analyse the moderating effect of environmental human resource management practices, we calculated a latent interaction variable (pollution prevention $\times$ environmental human resource management). Using the standardized or centered indicators of the predictor variable (i.e. pollution prevention) and the moderator variable (i.e. environmental human resource management), product indicators were then developed by creating all possible products from the two sets of indicators. These product indicators are used to reflect the latent interaction variable. Due to the characteristics of the PLS algorithm, the high number of indicators of the interaction term does not constitute a problem. On the contrary, Chin *et al.* (2003, p. 35) recommended sample sizes of approximately 100 with six to eight indicators per main effect constructs. Given smaller sample sizes or numbers

of indicators, PLS tends to underestimate the structural paths among constructs. These authors state that:

> [. . .] based on our understanding of the PLS algorithm, we would expect it to perform better than a strategy of simply summing the individual indicators to create a composite score and using multiple regression.

Results

To assess the reliability of the latent variables estimated by PLS, the composite reliabilities and Cronbach's α were calculated and presented in Table I. Overall, the composite reliabilities of the constructs were high (at or above 0.82) and Cronbach's α values surpass the level of 0.70 established by Nunnally (1978) to ensure the internal consistency of empirical scales.

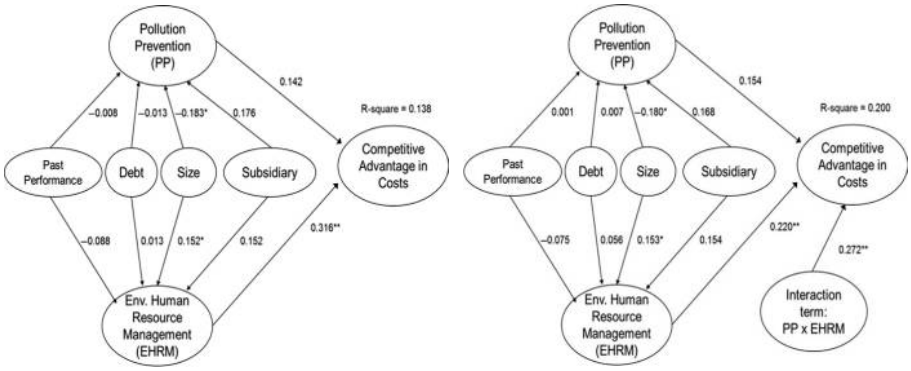
In each scale, most of the factors' loadings are above the threshold of 0.70, with the exception of two indicators of the environmental human resource management scale (0.59 and 0.56) and one indicator of the differentiation advantage scale (0.65). In practice, it is common to find that several measurement items in an estimated model have loadings below the 0.7 threshold, particularly when new items or newly developed scales are employed (Hulland, 1999). Indeed, several studies have indicators scoring between 0.4 and 0.5 on theoretical grounds (Fornell *et al.*, 1990). In our model, those items with loadings below the 0.7 threshold have been retained as all respective *t*-values are above 3.0 and the potential loss of information derived from their deletion does not justify the improvement in terms of reliability.

Two different path-models were estimated. The first one considered cost competitive advantage as the dependent variable, while the second considered differentiation competitive advantage. To assess whether the interaction effect and main effects were significant, a bootstrap resampling procedure (Efron and Tibshirani, 1993) was performed (200 resamples). Control variables were considered to affect the level of deployment of both pollution prevention and environmental human resource management practices.

In the case of cost advantage, the results (Figure 1, panel B) show a non-significant path coefficient from pollution prevention to cost advantage (standardized β of 0.154; $p > 0.05$), a significant path coefficient from environmental human resource management to cost advantage (0.220; $p < 0.01$) and a significant interaction effect (0.272; $p < 0.01$) with a total R^2 of 0.20. Thus, these results imply that one standard deviation increase in environmental human resource management will not only impact cost advantage by 0.220, but it would also increase the impact of pollution prevention

Table I. Latent variables' reliability

Latent variable	Items	Composite reliability index	Cronbach's α
Pollution prevention (PP)	4	0.832	0.736
Environmental human resource management (EHRM)	6	0.841	0.772
Competitive advantage in costs	3	0.825	0.701
Competitive advantage in differentiation	5	0.855	0.774
Interaction term: PP × EHRM	24	0.869	0.871



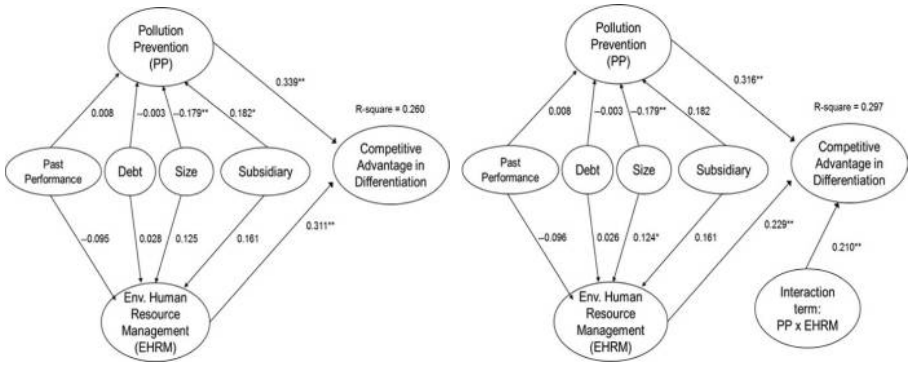
Notes: Significant at: * 0.05 and **0.01 levels; panel A: results of the main effect model; panel B: results of the interaction model

Figure 1.
Results of the cost advantage model

on cost advantage from 0.154 to 0.426. The main effect model (Figure 1, panel A), as expected, resulted in slightly higher standardized β and a smaller R^2 of 0.138. The size of the interaction effect (Cohen's f[1]) is therefore 0.31, which constitutes a large effect (Cohen and Cohen, 1983).

When differentiation advantage is the dependent variable (Figure 2, panel B), results show a significant path coefficient from pollution prevention to differentiation advantage (0.316; $p < 0.01$), a significant path coefficient from environmental human resource management to differentiation advantage (0.229; $p < 0.01$) and a significant interaction effect (0.210; $p < 0.01$) with a total R^2 of 0.297. The main effect model (Figure 2, panel A) resulted in a smaller R^2 of 0.260. Thus, the interaction term has an effect size of 0.12, which is a small to medium effect.

Overall, the results provide partial support for *H1*, as an extensive use of pollution prevention practices has a direct effect on differentiation competitive advantages, but not on cost competitive advantages. Human resource management practices have



Notes: Significant at: *0.05 and **0.01 levels; panel A: results of the main effect model; panel B: results of the interaction model

Figure 2.
Results of the differentiation advantage model

a direct positive effect on achieving advantages in costs and differentiation and they moderate the relationship between pollution prevention and cost and differentiation competitive advantages. On the whole, these results provide support for *H2*.

With a view to analysing how a high number of parameters affects the results given by PLS, we reduced the number of indicators of pollution prevention and environmental human resource management constructs, following the procedure described in Mathieu and Farr (1991, p. 128). The pollution prevention scale was reduced from four items to two indicators, while the human resource management scale was reduced from six items to three indicators. To establish the indicators for each multi-item measure, we averaged the items with the highest and lowest loadings to form the first indicator. The items with the next highest and lowest loadings were then used to form the second indicator and so forth until all items were assigned to one of the indicators for each variable. The interaction term had six indicators. Estimations of the new model resulted in a standardized β of 0.148 ($p > 0.05$) from pollution prevention to cost advantage, 0.250 ($p < 0.01$) from environmental human resource practices to cost advantage and an interaction effect of 0.209 ($p < 0.01$) with a total R^2 of 0.175. The main effect model resulted in slightly higher standardized β and a smaller R^2 of 0.140. The interaction effect, therefore, had an effect size of 0.20, which is a medium to large effect. In the second model (differentiation competitive advantage), the results showed a path coefficient of 0.261 ($p < 0.01$) from pollution prevention to differentiation advantage, 0.214 ($p < 0.01$) from environmental human resource to differentiation advantage and 0.190 ($p < 0.01$) from the interaction term to differentiation advantage ($R^2 = 0.233$). Coefficients estimated in the main effect model were significant, with an R^2 of 0.202. The interaction effect had an effect size of 0.13 (a small to medium effect).

As expected, as the number of indicators decreases, measurement loading estimations increase and structural paths estimations decrease. Although this is a well-known bias of PLS, the results indicate the significance of the interaction term and support *H2*.

Discussion and conclusions

Human resource practices related to environmental issues constitute a strategic resource which can allow competitive advantages in costs and differentiation to be obtained. The availability of staff with skills and knowledge of environmental protection, together with practices which encourage the setting up of environmental initiatives, constitute an incentive to obtain competitive advantages in costs among the companies in the sample. Analysis of the moderating role of human resource management shows that companies with a high level of environmental human resource practices can benefit from the advantages in costs derived from the implementation of pollution prevention technologies.

As regards explaining the competitive advantages in differentiation related to environmental issues, two important aspects should be highlighted. First, pollution prevention can be considered as a strategic capability which has a positive influence in achieving competitive advantages in differentiation. This circumstance supports the idea that companies can apply measures which both protect the environment and improve their competitiveness by means of differentiation within the sector. On the other hand, human resource practices have a direct influence on companies' differentiation advantage, even considering the effect of pollution prevention. Second, firms which

implement pollution prevention technologies and develop environmental practices of human resources achieve a greater competitive advantage of differentiation. Overall the results show the relevance of considering that resources (including those based on environmental protection) are heterogeneously distributed and reveal that companies can obtain advantages in both costs and differentiation by applying prevention technologies and developing human resource management practices which contribute to their appropriate implementation.

Implications

Although some theoretical studies suggest that environmental practices may lead to both cost and differentiation advantages (Shrivastava, 1995b), there has been little or no empirical evidence. On the other hand, most studies on environmental management have focused on environmental strategies. In this manner, a firm's internal characteristics and its effects on environmental practices constitutes a second-tier investigation (Christmann, 2000, p. 675). In this respect, our results suggest that pollution prevention technologies constitute a valuable strategic resource for some companies and this allows them to obtain an advantage in differentiation based on their environmental strategy. Companies holding assets that complement the variety of environmental practices may have differentiation and cost advantages. To sum up, the results of this study suggest that further research in this area may focus on the analysis of firms' environmental strategies and how diverse choices are related to different resources and capabilities. Firms' environmental human capital constitutes a critical strategic resource to facilitate the implementation of pollution prevention technologies and to improve competitiveness. Thus, environmental human resource management practices have to be considered as critical activities of a firm's environmental strategy.

The inconsistency of the results in relation to the link between environmental management and financial performance may respond to the concomitant effects of the following three aspects. First, firms holding resources that complement environmental protection measures have access to the advantages of strategic capabilities which generate economic advantages. As these internal characteristics are not studied in most research studies analysing the relationship between environmental strategies and financial performance, the empirical results obtained are inconsistent. The second aspect may benefit from further research. Some companies may benefit (e.g. get competitive advantages) from applying pollution prevention measures without these advantages necessarily being translated into better performance than their competitors. Along the lines of the model proposed by McWilliams and Siegel (2001) for the case of investment in "assets of social responsibility", investment in environmental protection above and beyond what is legally required may not have a significant effect on profitability, since the company's costs and the sale price of the product both increase. In this sense, the profitability of a company having obtained an advantage in differentiation via the implementation of environmental technologies may be the same as that of other companies which base their strategy on cost minimisation or on differentiation based on another attribute. Finally, to understand the link between proactive environmental practices (e.g. pollution prevention and environmental human resource management practices) and business performance, it is important to consider the motivations for adopting these practices (Darnall *et al.*, 2008). Previous research has relied on institutional theory to suggest that firms introduced environmental practices

with a view to increasing their internal efficiency and external legitimacy (Hoffman, 2000). Darnall *et al.* (2008) found that firms adopting advanced environmental practices as consequence of institutional pressures (as opposed to complementary resources and capabilities) experienced second-tier levels of performance. Thus, a firm's use of pollution prevention technologies and environmental human resource management practices may improve performance, if the adoption of such practices is not only the result of conforming to institutional pressures. Studies addressing these issues should focus on diverse settings and, preferably, using longitudinal samples.

Limitations

A set of limitations of the present article should be noted. First, the cross-section empirical study design does not allow clear causal relationships to be inferred from the results of PLS. For instance, in the case of chemical companies environmental management practices and complementary resources which allow companies to obtain value may be characteristic of the most profitable companies. Nevertheless, there are some indications that refute the fact that these companies experience advantages in costs and differentiation derived from environmental practices to a greater extent than companies with less profitability. The correlation between the profit in previous years and the complementary assets (human resource practices) is very low and not significant ($r = 0.03$). Another possibility is that the most profitable companies are those which can apply environmental protection measures since they possess a greater quantity of resources. However, the correlation between profit growth and each of the environmental practices is very low or even negative.

Second, there are additional limitations with regard to the data themselves and their sources. Although the data have been confirmed wherever possible by means of alternative sources (e.g. size), this has not been possible in the case of all the variables. The possibility exists, therefore, that the data include a subjective component which is difficult to quantify.

Note

1. Calculated as (R^2 (interaction model) – R^2 (main effect model))/R^2 (interaction model).

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About the authors

Dr Eva Carmona-Moreno is an Assistant Professor of Strategic Management at the University of Almería. She received her PhD from the University of Almería and her current research interests focus on environmental management and strategic human resource management.

Dr José Céspedes-Lorente is a Professor of Management at University of Almeria. He received his PhD from the UNED and his current research interests are strategic management, environmental management, organizational learning, and entrepreneurship. José Céspedes-Lorente is the corresponding author and can be contacted at: jcespede@ual.es

Dr Javier Martinez-del-Rio is an Associate Professor of Management at the University of Almería. He received his PhD from the University of Almería and his research topics of interest include environmental management, geographical clusters and entrepreneurship.

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