The effect of manufacturing proactivity on environmental management: an exploratory analysis

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**THE EFFECT OF MANUFACTURING PROACTIVITY ON ENVIRONMENTAL
MANAGEMENT: AN EXPLORATORY ANALYSIS ***

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THE EFFECT OF MANUFACTURING PROACTIVITY ON ENVIRONMENTAL MANAGEMENT: AN EXPLORATORY ANALYSIS

Abstract

This paper studies the effect of manufacturing proactivity, understood as the company's interest in adopting new developments in the production and operations area, on environmental proactivity, manifested by the implementation of voluntary environmental management practices. It is theoretically argued that there is a positive link between both organizational features and based on a sample of 184 companies from three industrial sectors, it is verified that manufacturing proactivity is a good predictor of environmental proactivity. It is concluded that environmental proactivity tends to be a distinguishing attribute of the companies where the operations function plays a distinctive role.

Keywords: Environmental proactivity, manufacturing proactivity, environmental management

INTRODUCTION

Over the last few years, social concern about the deterioration of the natural environment has grown and fed the desire to reach what has been called ‘sustainable development’. As a consequence, the natural environment has become a necessary and unavoidable factor to take into account in the company’s strategic planning processes. Some companies have chosen to implement a wide range of environmental management practices which by far exceed regulatory requirements, thus showing a high degree of environmental proactivity. The objective of this paper is to study the role of a company’s manufacturing proactivity, understood as its degree of interest in reproducing the most advanced and innovative production and operations practices, as a determinant factor of this environmental proactivity. More precisely, we study to what extent the generalised implementation of advanced manufacturing practices affects the implementation of environmental management practices.

This research objective is motivated by the empirical findings of González-Benito and González-Benito (2005), who analysed the relationship between environmental proactivity and business performance. Although some previous papers had provided support for the existence of a positive relationship (e.g. Russo and Fouts, 1997; Sharma and Vredenburg, 1998; Klassen and Whybark, 1999b; Christmann, 2000), González-Benito and González-Benito (2005) showed that, when the effect of the implementation of certain representative advanced production and operations management practices is taken into account, this relationship is not forceful and appears to be significant only for some environmental practices and certain performance indicators. This paper indirectly revealed the powerful effect of the implementation of advanced and innovative production practices on operational and financial performance, a question that was specifically approached with greater detail in a subsequent paper (González-Benito, 2005). However, the

empirical results of González-Benito and González-Benito (2005) also suggest that the role played by environmental proactivity loses importance and becomes marginal when the implementation of advanced production practices is taken into account. In fact, this paper shows a high correlation between the adoption of environmental practices and the implementation of advanced production practices. This led us to think that manufacturing proactivity might be an important antecedent of environmental proactivity able to explain most of the highest performance shown by the companies committed to the preservation of the environment. It is therefore important to theoretically and empirically explore the relationship between these two concepts, manufacturing proactivity and environmental proactivity, in order to ascertain the extent to which we are actually studying manufacturing proactive firms when studying environmentally proactive firms. The results would help us to know the extent to which the competitive effects of environmental proactivity can become confused with the competitive effects of having more sophisticated and advanced production management systems.

The interest of this study also lies in several other different aspects. First, this paper contributes to enriching the literature aimed at identifying the determinant factors of environmental management practices implementation. Stakeholder pressure (Henriques and Sadosky, 1999), managerial values and motivations (Bansal and Roth, 2000; González-Benito and González-Benito, 2006), firm size (Arora and Cason, 1996; Levy, 1995), location of facilities (Vastag et al., 1996), equipment age and investment in advanced manufacturing technologies (Klassen and Whybark, 1999a), organizational slack (Bowen, 2002), and strategic proactivity (Aragón-Correa, 1998) are some of the previously studied factors.

Secondly, although all these determinant factors help to delineate the profile of those companies committed to the natural environment, the study of manufacturing proactivity goes beyond this by

tackling the importance and implications of the operations function for environmental management. That is, this paper implicitly studies to what extent a company's environmental implication arises from and builds on an active and consolidated operations function.

Thirdly, the consideration of manufacturing proactivity questions to what extent environmentally conscious management is only one more challenge for the company, as were just-in-time production, total quality management, or partnership sourcing. That is, just as in the study by Aragon-Correa (1998), present in this paper is the idea that environmental management responds to a company's internal desire for improving, innovating and facing new challenges. Nonetheless, it is implicitly argued here that this desire must be strongly present and settled in the production and operations function.

The paper is structured in six sections. Sections one introduces the concepts of environmental proactivity and manufacturing proactivity. Both concepts are related in section two, where the research hypothesis is posed and commented upon. Section three explains the research methodology and section four describes the results. Section five is devoted to the discussion of results and the paper ends in section six where the major conclusions are summarised.

1. THE CONCEPTS OF ENVIRONMENTAL PROACTIVITY AND MANUFACTURING PROACTIVITY

Environmental proactivity

The environmental proactivity of a company is defined in this paper as *the tendency of an organization to implement voluntary management practices aimed at improving environmental performance or to establish the systems that make such improvement possible*. Thus, environmental proactivity reflects the company's commitment to the natural environment. Environmental proactivity is usually presented in opposition to environmental reactivity, which consists of making only the minimal compulsory changes required to meet environmental regulations and which can be understood as the zero proactivity stage. Thus, environmental proactivity opens a space for the progress of companies where different strategies and postures can be developed.

In the literature on the strategies, postures or approaches to environmental management two levels of analysis must be distinguished: (1) the identification and conceptualisation of different strategies or stages; and (2) the identification of dimensions or factors upon which such strategies are defined (the dimensions of the space for progress mentioned above). As pointed out by González-Benito and González-Benito (2005), with regard to the second aspect, we can distinguish between one-dimensional and multidimensional studies. That is, there are companies follow a linear and single path when developing their commitment to the natural environment and papers recognising that there is no single path towards proactivity and that the diversity of existing environmental management practices give rise to different manifestation of strategic proactivity. In the first category, we can find conceptual works such as those of Hunt and Auster (1990), Roome (1992) and Winsemius and Guntram (1992) and empirical papers such as Sharma and Vredenburg (1998), Henriques and Sadorsky (1999) and Buysse and Verbeke (2003). In the second category, we can find papers such as Vastag et al. (1996), Azzone et al. (1997), Klassen and Angell (1998), Aragon-Correa (1998) or Klassen and Whybark (1999a),

which distinguish different dimensions or factors to classify or contextualize environmental strategies.

All these papers reveal that there are different types of proactive initiatives and practices, and that they might not always be reduced to a single dimension. However, there is no conclusive evidence as to how voluntary environmental practices become grouped into dimensions and what these dimensions are. This reasoning leads us to think that in order to measure environmental proactivity it is important (1) to take into account as broad a range as possible of environmental practices, and (2) to adopt an exploratory approach since previous research does not allow us to shape implementation dimensions a priori.

Manufacturing proactivity

Manufacturing proactivity is defined in this paper as *the tendency of an organisation to implement all those practices, tools or management systems considered the most advanced, modern and promising within its production and operations function*. It is therefore necessary to identify such practices previously. As pointed out by Gonzalez-Benito (2005), the literature that talks about ‘modern manufacturing practices’ (Bolden et al., 1997), ‘manufacturing process innovations’ (Bates and Flynn, 1995; Flynn et al, 1997), ‘capability building programmes’ (Ward et al., 1994), ‘best practice methods ’ (Hendry, 1998) or ‘world-class practices’ (Voss and Blackmon, 1996) indicates that there are a series of production management strategies, initiatives or techniques that draw a large share of the attention of operations management researchers and constitute the forefront of the operations management field.

Drawing on this literature, Table 1 gathers 10 practices which have been pointed out as new challenges for the operations function. This table also indicates some authors who have explicitly mentioned them or have mentioned other related issues in their lists of advanced or leading manufacturing practices. In particular, these 10 practices are closely linked to the concept of world-class manufacturing and take in many of the dimensions, principles and practices included in the seminal works of Hayes and Wheelwright (1984) and Schonberger (1986). In addition, the list includes Just in Time (JIT) and Total Quality Management (TQM), which, according to Flynn et al. (1999), should be added to the Hayes and Wheelwright dimensions. Most of the practices selected are also included in the lists of world class practices of Voss and Blackmon (1996). Thus, Table 1 in particular leads us to think that the selected practices are typical of world class manufacturers, although they do not necessarily define them.

INSERT TABLE 1 HERE

Regardless of whether they are related to world class manufacturing or to other literature, it seems clear that the practices in table 1 have played a main role in the operations management literature and they are still considered advanced and promising manufacturing practices. It is therefore assumed in the empirical part of this paper that the degree of implementation of this list of practices constitutes a measure of the manufacturing proactivity of the company. To some extent, this implies assuming that manufacturing proactivity is an attribute of world class manufacturers.

Although some of the practices are more specific than others as regards content and application and there is also some overlapping and complementarities between some of them, this should not be a problem since manufacturing proactivity is expected to manifest through the

implementation of innovations and new practices at different domains and levels of the operations function and represents a latent construct underlying such implementation.

2. RELATIONSHIP BETWEEN ENVIRONMENTAL PROACTIVITY AND MANUFACTURING PROACTIVITY

The question approached in this paper is whether there is a link between manufacturing proactivity and environmental proactivity. In particular, do those manufacturers that show a certain manufacturing proactivity and strive to adopt the more promising tendencies in operations management feel inclined to develop practices aimed at improving their environmental performance? Two compatible arguments lead us to think that the answer to this question is affirmative. These arguments have to do with the fashion effect and the exploitation of resources, capabilities and complementarities.

Fashion effect. The management area has been subjected to continuous fashions and fads which propose innovative approaches and techniques for improving organizational performance. Some of them have remained as accepted and acknowledged management practices and others have been abandoned as failures (Gibson and Tesone, 2001). A number of the practices in Table 1 have been considered management fashions or part of some fashion (see Carson et al., 1999, 2000). This is the case of TQM or employee empowerment, for example. On the other hand, given that environmental proactivity has also been presented as a way to improve competitive performance (e.g. Porter and Van der Linde, 1995; Maxwell et al., 1997; Russo and Fouts, 1997), the implementation of environmental management practices can also be considered a management fashion since, with some nuances, it fits the definition proposed by Carson et al.

(1999): 'managerial interventions which appear to be innovative, rational, and functional and are aimed at encouraging better organizational performance'. Within this context, the effect of manufacturing proactivity on environmental proactivity can be viewed as derived from the effect that the adoption of various management fashions in the past has had on the adoption of a management fashion today.

According to Abrahamson (1996), the adoption of management fashions is motivated by three psychological states: frustration, boredom and striving for novelty, and striving for status differentiation. The first motivation refers to the case in which a company implements a management fashion to overcome a sense of frustration and disappointment with previous experiences. Given that the potential benefits of many management fashions have initially been exaggerated, it is not surprising to think that, to a greater or lesser extent, this sense of frustration and disappointment is likely to appear as a consequence of the previous adoption of management fashions. This would lead the company to try a new fashion. If the second and third motivations mentioned above encouraged the adoption of other management fashions in the past, they probably continue to be present in the company and motivate the adoption of new fashions. In fact, the desire to distinguish the company involves adopting new management fashions when old management fashions have become widespread (Abrahamson, 1996).

This reasoning suggests that a long record of adopting management fashions in the past leads to the adoption of new management fashions on a continuous basis. In the particular case studied in this paper, this leads us to think that manufacturing proactivity to some extent motivates the implementation of environmental management practices. Nonetheless, if the intention of managers is to differentiate the company or to point out their dynamism, one might think that they will be mainly interested in implementing those environmental practices which are more

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3 perceivable by external stakeholders (e.g. environmental certification). The following second
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5 argument supports the idea that manufacturing proactivity also motivates other environmental
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7 practices which are not so visible from the outside.
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12 *Exploitation of resources, capabilities and complementarities.* The resource-based view of the
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14 firm has its origin in the work of Wernerfelt (1984) and has subsequently been developed in a
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16 large number of papers (e.g. Barney, 1991; Grant, 1991; Mahoney and Pandian, 1992).
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18 According to this approach, the competitive advantage of a company is a function of its portfolio
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20 of inimitable resources and distinctive capabilities. Formulating a resource-based strategy
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22 involves identifying such resources and capabilities so that the potential opportunities derived
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24 from them can be taken advantage of.
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32 The argument at this point is that the implementation of advanced manufacturing practices such
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34 as those in Table 1 allows the company to generate resources and capabilities which facilitate the
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36 implementation of environmental management practices, especially those requiring a
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38 transformation of the operations system. The company has a flexible workforce used to taking on
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40 new tasks, a design department able to innovate continuously, a flexible production system with
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42 optimal information management, an organizational culture based on continuous improvement
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44 and customer satisfaction, and a base of receptive suppliers inclined to collaborate. In summary,
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46 it has a dynamic, flexible and market-oriented productive system which facilitates change and
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48 quick response to external pressures and, in particular, makes the development of environmental
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50 policies easier. The company will find it easier to design and develop environmentally friendly
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52 products, to introduce modifications in the logistics chain even when they affect suppliers, to
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54 allocate environmental responsibilities to employees, or to undergo structural and infrastructural
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56 transformation in its production facilities.
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In addition, it must be taken into account that there might also be some complementarities between some of the operational practices included in Table 1 and environmental management, that is, some advanced manufacturing practices may in themselves contribute to improving environmental performance. For example, JIT production is characterised by the use of reusable containers and the elimination of packaging in both internal and external material flows (Ansari and Modarress, 1988). In this respect, Klassen (2000) and King and Lenox (2001) provide empirical evidence about the complementarities between the green and the lean approaches to management. TQM philosophy builds on the quality assurance paradigm, that is to say, on the purpose of doing things well the first time, thus reducing rates of defective products and, therefore, the amount of residue (Dale et al., 1994; Hackman and Wageman, 1995). These observations indicate that certain economies of scope might appear when some manufacturing approaches and certain environmental management practices are applied together.

These two arguments presented above lead us to propose the following hypothesis:

Hypothesis 1: The stronger the manufacturing proactivity of a company, the stronger its environmental proactivity

It must be taken into account that, given that manufacturing proactivity can be considered a component of strategic proactivity, hypothesis 1 can be considered a more specific derivation of the hypothesis of Aragón-Correa (1998) on the effects of strategic proactivity on environmental proactivity.

3. METHODOLOGY AND ANALYSIS

Data

The approached population consisted of medium and large Spanish companies in three industrial sectors: chemical products, electronic and electrical equipment, and furniture and fixtures. All the entries with more than 100 employees in each of the selected industrial sectors were extracted from the Dun & Bradstreet census of the 50,000 largest Spanish companies. The only exception was made for the pharmaceutical companies (SIC 283), which were not included in the study. Thus, the target population finally consisted of 428 companies, 156 of which were in the chemical sector, 211 in the electronic and electric equipment sector, and 61 in the furniture sector.

The data was collected through a postal survey during the second quarter of 2002. The questionnaire, which covered different aspects of the environmental activity of the company, was first commented upon with managers and experts involved in environmental management, and then subjected to a pretest in 9 companies, three in each sector. This led to improvements in wording and structure which made the questionnaire easier to understand and eliminated possible ambiguities.

Given that the completion of the questionnaire requires a deep knowledge of the productive processes and the environmental management practices of the company, it was addressed to the operations/production manager of each company. In order to avoid inconsistencies derived from the diversified structure of some companies or from the differing portfolio of practices used in each production facility, data collection was focused on the company's largest production facility

linked to the industrial sector considered. In all the cases, the questionnaire was accompanied by a presentation letter and a pre-paid envelope for return.

It was also preceded by a phone call to identify the appropriate addressee and to ask for their collaboration. A second phone call was made to all the companies that did not return the questionnaire some days after the mailing. Finally, a total of 184 valid questionnaires was obtained, which means a global response rate of 42.99%, which in turn corresponds to rates of 40.38%, 45.01% and 42.62% for the chemical, electronic equipment and furniture industries, respectively.

In order to assess sample representativeness, statistical comparisons between collaborators and non-collaborators were carried out regarding two magnitudes included in the Dun&Bradstreet database: number of employees and annual turnover. Table 2 summarises the results of these comparisons as a whole and by sectors. No significant differences were detected for a confidence level of 95%.

INSERT TABLE 2 HERE

Measures

Manufacturing Proactivity

Consistent with the theoretical exposition of the paper, a measure of manufacturing proactivity was built from the degree of implementation of the ten advanced manufacturing practices in Table 1. Specifically, each company was asked to choose the degree of agreement with ten assertions

referring to the implementation of such practices. A six point Likert scale from 1 (not at all) to 6 (to a great extent) was used (see Appendix 1). In order to identify the dimensions underlying manufacturing proactivity, principal component analysis of the ten items was performed. Two factors had eigenvalues greater than 1, capturing 49.498% of the variance. Table 3 shows the practices along with the most common descriptive statistics. It also shows the structure matrix of the two selected factors resulting from a Varimax orthogonal rotation. Factor loadings reflect that the first factor primarily takes in those practices which imply a greater cultural change within the organization. A high score on this factor means that the company thinks of employees as resources instead of costs, considers their suppliers as collaborators rather than competitors, and promotes dynamism and continuous improvement. In general, they all are practices directly related to the TQM principles. The second factor, on the other hand, mainly takes in practices that involve the adoption of specific tools or techniques in the production plant. The implementation of CAD/CAM systems, integrated information systems, advanced manufacturing technologies, and JIT systems characterises those companies with high scores on factor 2. Thus, the first factor measures a cultural dimension of manufacturing proactivity whereas the second factor measures a technical dimension.

INSERT TABLE 3 HERE

Environmental proactivity

A comprehensive and broad list of environmental management practices was built from the literature and each company was asked to rate the degree of implementation of each practice. Again, the rating format consisted of a six-point Likert scale (see Appendix 1). In order to identify the dimensions underlying the implementation of environmental practices, principal component

analysis was applied to the whole set of items. Table 4 shows the structure matrix after a Varimax orthogonal rotation, giving a total of four factors with eigenvalues higher than one, together accounting for 67.664% of the variance.

INSERT TABLE 4 HERE

Factor 1 mainly takes in practices related to the development of an Environmental Management System, that is, it reflects the extent to which the company has defined an environmental policy, has developed procedures for establishing environmental objectives, for selecting and implementing environmental practices, and for assessing the outcomes of such practices, has allocated environmental responsibilities, and has reported to its socioeconomic environment about its advancements in environmental management. In other words, factor 1 indicates the extent to which the company has established planning and organizational mechanisms to implement and control environmental initiatives in a rational and coordinated way. This dimension has thus been labelled as 'planning and organization'. Practices such as these were considered by Henriques and Sadorsky (1999) to identify environmental commitment profiles, in what can be seen as an approach primarily focused on environmental planning. This set also includes practices loading on the information and education factor of Aragón-Correa (1998) and considered within the systems analysis and planning dimension of Klassen and Whybark (1999a).

The practices primarily loading on the other three factors involve a transformation of the operations function, which, according to several authors, plays an essential role in environmental issues (Angell and Klassen 1999; Gupta, 1994; Inman, 1999; Sarkis, 1995, 2001; Pilkington and Fitzgerald, 2006). Factor 2 mainly reflects the implementation of environmental management practices related to logistics and supply chain management. Several authors have distinguished

this type of environmental practices (Wu and Dunn, 1994; Handfield et al., 1997; Bowen et al., 2001; Min and Galle, 2001; Vachon and Klassen, 2006; Linton et al., 2007). This dimension has thus been labelled as 'logistics processes'. Factor 3 mainly takes in those practices related to the ecologically responsible design of new products. These practices not only involve replacing polluting and hazardous materials with other green supplies or reducing resource consumption, but they also reflect a commitment to the product even after it has been sold through 'design for disassembly' (Shrivastava, 1995; Viswanathan and Allada, 2006). This dimension has consequently been labelled as 'product design'. Finally, factor 4 primarily takes in practices reflecting a transformation in the internal production processes of the company. It includes remediation and control practices such as the installation of emission filters or waste separation and preparation systems, together with prevention practices such as the use of renewable energy resources, or the contemplation of environmental criteria for production planning. This dimension has thus been labelled as 'internal production processes'.

Some additional questions included in the questionnaire acted as controls for the validity of data. Each company was asked to mark its situation as regards ISO14001 certification according to four stages: (1) certification not considered, (2) certification considered for the near future, (3) certification in process, and (4) certification awarded. The 'planning and organization' factor (factor 1) captures most of the environmental management practices required for ISO14001 certification. Thus, it is expected that the more advanced the ISO14001 stage at which the company is, the higher its score in factor 1. An ANOVA F-test ($F = 58.425$, $p = 0.000$) and subsequent Tukey tests show that the mean of factor 1 at each stage is significantly higher than in the previous one, thus confirming the expected pattern. This result not only proves the convergent validity of factor 1, but it also indicates that managers completed the questionnaire consistently and it therefore constitutes a proof of the validity of the collected data.

The questionnaire also included some questions devoted to identifying managerial motivations (in particular, ethical motivations). Managers' concern about the natural environment is not related to the implementation of some environmental practices. This leads us to think that managers have distinguished quite well between what is desirable and what has really been done.

Analysis

The analysis of the relationship between environmental proactivity and manufacturing proactivity was conducted at the level of the factorial measures through multiple regression analysis. The four factors describing the environmental orientation of the companies were interpreted as dependent variables and the two dimensions of manufacturing proactivity were included as independent variables.

In order to isolate the relationship studied, four control dimensions were added to the group of independent variables: (1) company size, measured as hundreds of employees; (2) plant equipment age, measured by the number of five-year intervals from the acquisition of the main productive equipment in use; (3) company internationalization, included by using a binary variable distinguishing those companies which are part of multinational groups; and, (4) the industrial sector, which required the introduction of two binary variables distinguishing the chemical and electronic and electrical equipment sectors, respectively.

In order to assess the extent of multicollinearity among independent variables, different statistical tests shown in Table 5 were conducted according to the properties of the different scales combined in the study. Significant correlations between pairs of manufacturing proactivity and

environmental proactivity dimensions provide initial support for hypothesis 1. With respect to the control variables, given that the relationships are not very strong and that collinearity does not directly affect the relationship studied in the hypothesis, all five control variables were kept in the study.

INSERT TABLE 5 HERE

Of special interest for the analysis of hypothesis 1 are the relationships among the control variables and the manufacturing proactivity factors. In this respect, it was detected that control variables were to a greater or lesser extent significantly correlated with the dimensions of manufacturing proactivity. Thus, in order to control for collinearity, two explanatory models were considered. Model 1 includes only the control variables as independent variables and model 2 incorporates each of the two manufacturing proactivity factors. Table 6 summarises the regression results.

INSERT TABLE 6 HERE

4. RESULTS

With respect to regression modelling in Table 6, model 1 includes only the control variables. The coefficient for company size is positive and significant for three of the four dependent variables, indicating that there are scale economies associated with environmental management. Plant equipment age shows negative coefficients in all cases. Although these coefficients are not significant, the negative sign is consistent with the idea that the implementation of some

environmental management technologies may turn out to be easier and less costly when installed concurrently with new productive equipment (Klassen and Whybark, 1999a). The internationalization of the company presents positive coefficients in the four regressions, and they are all significant except for the logistics processes dimension. These results support a positive effect of knowledge transfer among plants and suggest the existence of scale economies also at the corporate level (Christmann and Taylor, 2001, 2002; Gupta and Govindarajan, 2000). As for sector variables, the data suggest that chemical and electronic companies are more active in implementing planning and organization environmental practices. In general, the results obtained for the control variables suggest the appropriateness of having included them in the analysis and are consistent with previous literature.

The results for model 2 show that the introduction of both dimensions of manufacturing proactivity increases the explanatory power of the model (R^2) significantly. This is especially important given that another five explanatory variables have already been included in the equation. Furthermore, all the coefficients of these two dimensions are positive and many of them are significant with a level of confidence above 95%. Thus, results provide notable support for hypothesis 1. In particular, both cultural and technical proactivity appear as significant predictors of the implementation of logistics related environmental practices. Product design environmental practices are explained by technical manufacturing proactivity and the implementation of planning and organization and internal production processes related practices responds only to the cultural manufacturing proactivity dimension.

5. DISCUSSION

The first question to be discussed refers to the interpretation of the factorial measures considered in the study. In spite of the overlapping and complementarities between some advanced manufacturing practices mentioned in section 2, there is no one single dimension underlying the implementation of these practices. Rather, manufacturing proactivity is manifested in two different forms, one involving a cultural evolution of the company and the other involving a technical transformation. These respectively reflect the interest of a company to adopt the most modern management values and thinking and the most advanced tools and techniques. This result implies that the effect of manufacturing proactivity on other parameters of the company might depend on the way in which such proactivity is manifested. This question is to some extent anticipated by Ward et al. (1994), who use different scales to measure this concept.

As regards the measures for environmental proactivity, the exploratory analysis reveals that some companies give more importance to the implementation of planning and organization practices. In an extreme interpretation, they could be viewed as companies pursuing environmental certifications but neglecting a deeper environmental transformation of operations. The dimensions resulting from the analysis also establish a differentiation between product related and process related environmental practices, supporting the scheme of Sarkis (2001) and the empirical approach of Gilley et al. (2000). Within the group of process related practices, implementation patterns also distinguish between the environmental transformation of internal processes and the conversion of logistical and supply chain processes. Thus, the results indicate that those companies involved in an environmental transformation of their operations systems tend to focus on introducing changes in product design, internal processes or logistics processes.

These results confirm the multidimensional nature of environmental proactivity. Voluntary environmental practices tend to be implemented in separated groups, each group giving rise to

different proactive strategies. The grouping identified in this paper suggests that environmental strategies might be linked to the functional organisation of the company, perhaps since the environmental values are different within each department of the organisation. In this respect, we could talk about environmentally sound design departments, production departments and logistics departments. This piecemeal approach to environmental management might have its origin in divergent functional motivations and attitudes. This might to some extent reveal the importance of coordination between functional areas for the configuration of environmental strategies (McGee, 1998).

With respect to the relationship between manufacturing proactivity and environmental proactivity, the data provide notable support for hypothesis 1. There is a significant effect of the cultural dimension of manufacturing proactivity on the implementation of planning and organization practices. These environmental practices are often linked to an environmental certification and, as a consequence, are easily identifiable by external stakeholders. This result provides certain validity for the fashion effect argument, which presented manufacturing proactivity as a potential driver for the implementation of externally perceivable environmental practices to satisfy differentiation desires. Nonetheless, the results reveal that the antecedent is cultural manufacturing proactivity instead of technical manufacturing proactivity, perhaps because the former is also more externally perceivable.

The analysis also confirms a positive relationship between manufacturing proactivity and the other three environmental dimensions, although some interesting issues come up in this case. Cultural manufacturing proactivity denotes that the company is a continuous improver, cultivates motivation and capabilities in the workforce, integrates suppliers in the processes and is oriented to meeting customers' requirements, especially in product design. Technical manufacturing

proactivity denotes attributes such as production flexibility, information efficiency, speed in production and design and compliance with specifications. All these capabilities turn out to be positive for the implementation of environmental practices related to the transformation of logistics processes. However, the implementation of product design environmental practices is only favoured by the second group of capabilities whereas the implementation of internal production environmental practices is only explained by the presence of the first group of capabilities.

On the one hand, these results seem to indicate that the companies with the more sophisticated and flexible production systems encounter problems in introducing environmental changes into their production processes. In other words, the adoption of changes in production planning to gain environmental economies, the introduction of separation and control processes or the environmental redesign of production processes do not seem to be compatible with practices such as JIT, CAD/CAM and the implementation of integrated information systems. In particular, this to some extent indicates that, in spite of contributing to improving environmental performance (Klassen, 2000; King and Lenox, 2001), initiatives such as JIT do not facilitate the implementation of certain environmental practices. On the other hand, companies with more expertise in product design (cultural proactive manufacturers) are not the most interested in introducing green products. They seem to devote their efforts to incorporating other kinds of features in their products. This might mean that Spanish customers tend to prioritize other product attributes over ecological ones.

6. CONCLUSIONS

The purpose of this paper has been to analyse the effect of manufacturing proactivity on environmental proactivity and to theoretically justify a causal relationship between them. Three concluding remarks derive from the development and results of the study. First, environmental proactivity does not arise in a one-dimensional way as the uniform implementation of a group of practices; rather, it contains different, although related, dimensions. This gives rise to different behavioural patterns, each emphasizing different portfolios of environmental practices. At the operational level, the data collected for this study suggest three directions of environmental proactivity: product design, internal production systems, and supply chain and logistics management.

Second, although the empirical development of the paper only supports a positive relationship between manufacturing proactivity and environmental proactivity, there are two reasons to think that a causal relationship exists between them. On one hand, manufacturing proactivity reflects an interest in implementing some innovative production practices which, in many cases, have been considered as management fashions. Environmental proactivity has frequently been presented as a promising management innovation and could be understood as a new management fashion. The literature in this respect suggests that an extensive record of having adopted management fashions in the past leads to the continuing adoption of new management fashions. This responds to a continuous search for differentiation and a managerial need to be original. In this sense, proactive manufacturers might view certain environmental management practices as a new way to differentiate the company. On the other hand, manufacturing proactivity is manifested by the implementation of advanced manufacturing practices which in turn engender new resources and capabilities which can to a great extent facilitate the

implementation of environmental practices. In other words, the company can take advantage of the skills and complementarities generated by the implementation of advanced manufacturing practices.

Third, it must be taken into account that the degree of manufacturing proactivity can be understood as an indicator of the strategic importance of the production and operations function within the company. In this sense, the degree of environmental proactivity can also be seen as a characteristic feature of those companies whose operations function supports to the greatest extent the strategic objectives of the firm. Thus, it might be seen as an organizational feature derived from the concept of production competence (Cleveland et al., 1989; Vickery, 1991; Schmenner and Vastag, 2006).

This research is not exempt from limitations. The overcoming of such limitations opens future research directions. On the one hand, different arguments have been used to explain the causal effects proposed in the hypotheses, but empirical results allow us to say little about the relations of dominance between them. New hypotheses should be developed to compare arguments and refine theoretical explanations. On the other hand, some methodological shortcomings must be recognized. Although subjective measures based on perceptions are frequently used in the literature, and they can be considered valid for a first approach to study the role of manufacturing proactivity in the environmental proactivity debate, a combination of objective and subjective measures in future research would be desirable.

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Appendix I. Details of the postal questionnaire

Measurement of manufacturing proactivity (examples)

	1 Not at all	2	3	4	5	6 To a great extent
We have strived to implement TQM philosophy and to achieve all those quality certifications which are valued in our industrial sector	☐	☐	☐	☐	☐	☐
We have implemented integrated information systems (ERPs) to manage supply, production and distribution planning and control (e.g. SAP R/3, ORACLE e-business suite, ...)	☐	☐	☐	☐	☐	☐
We have reduced the number of suppliers and fostered collaboration with them (e.g. joint product design and development, sharing of cost information, ...)	☐	☐	☐	☐	☐	☐

Measurement of environmental proactivity (examples)

	1 Not at all; only what regulation requires	2	3	4	5	6 To a great extent
We define long- term environmental objectives and plans which are formally documented	☐	☐	☐	☐	☐	☐
Our products are designed to facilitate disassembly in recycling processes	☐	☐	☐	☐	☐	☐
We have incorporated environmental performance criteria for supplier selection (e.g. ISO 14001 certification is required)	☐	☐	☐	☐	☐	☐
We sponsor environmental initiatives/events and collaborate with organizations devoted to environmental preservation	☐	☐	☐	☐	☐	☐

Table 1: A selection of advanced manufacturing practices

Practices	Hendry (1998) best practice methods	Ward et al. (1994) Capability Building Programmes	Bolden et al. (1997) Modern Manufacturing Practices	Bates and Flynn (1995) Manufacturing Process Innovations	Voss and Blackmon (1996) World-Class Practices	Hayes and Wheelwright (1984) and Flynn et al. (1999) 'World Class Manufacturing Practices	Schonberger (1986) World Class Manufacturing Lessons
Employee participation and involvement	✓	✓	✓	✓	✓	✓	Workforce participation
Employee training and development	✓	✓	✓		✓	✓	Workforce skills and capabilities
Collaboration with suppliers	✓		✓	Supplier reduction	✓		✓
Continuous improvement	✓					Incremental improvement approaches	
Total Quality Management	Improve quality and value for money		✓	✓	Customer orientation, quality vision	✓ Competing through quality	Quality as competitive weapon, Total Quality Control
Pioneering product designs and features	Design for products and processes				Design process	Competing through quality (customer orientation)	Design for the customer and without delay
Advance Manufacturing Technologies (AMT)		FMS, CNC, DNC	Automated Storage and Retrieval Systems		Automation	Rebuilding Manufacturing Engineering	
Just-in-Time production	Simplify the shopfloor			✓	Kanban	✓	✓
Integrated information systems (ERPs)	Use appropriate planning and control systems				Information Systems		
CAD/CAM technologies		✓	✓	✓		Rebuilding Manufacturing Engineering	✓

✓ means 'explicitly mentioned'

Table 2. Representativeness of sample

	Companies Population (sample)	Number of employees					Annual turnover (thousands of Euros)				
		100-199	200-499	500-999	>1000	χ^2 (p value)	<18000	18000-30000	30000-60000	>60000	χ^2 (p value)
Chemical Products	156 (63)	75 (27)	53 (22)	21 (10)	7 (4)	1.133 (.769)	12 (4)	35 (11)	41 (20)	68 (28)	1.569 (.669)
Electronic and electrical equipment	211 (96)	92 (37)	82 (35)	23 (14)	14 (10)	3.970 (.265)	50 (21)	44 (15)	62 (29)	55 (31)	2.842 (.417)
Furniture and fixtures	61 (27)	41 (20)	16 (6)	2 (0)	2 (1)	1.255 (.740)	38 (17)	10 (4)	8 (5)	5 (1)	1.309 (.727)
TOTAL	428 (186)	208 (84)	151 (63)	46 (24)	23 (15)	3.867 (.276)	100 (42)	89 (30)	111 (54)	128 (60)	3.028 (.387)

Table 3: Principal Component Analysis of Advanced Manufacturing Practices

Item	Mean (S.D.)	Factor 1 Cultural proactivity	Factor 2 Technical proactivity
Employee participation and involvement	4.26 (1.11)	.645	.281
Employee training and development	4.33 (1.24)	.738	.266
Collaboration with suppliers	3.94 (1.18)	.506	.473
Continuous improvement	5.28 (0.91)	.732	-.004
Total Quality Management	4.96 (1.29)	.590	.157
Pioneering product designs and features	4.84 (1.03)	.670	.176
Advance Manufacturing Technologies (AMT)	4.45 (1.16)	.439	.570
Just-in-Time production	4.02 (1.36)	.177	.704
Integrated information systems (ERPs)	4.76 (1.38)	.362	.416
CAD/CAM technologies	4.14 (1.82)	-.004	.787
Total variance explained: 49.498%			

Table 4. Principal Component Analysis of Environmental Management Practices

Practices	Mean (S.D.)	Factor 1 Planning and Organizational	Factor 2 Logistics Processes	Factor 3 Product Design	Factor 4 Internal Production Management
Explicit definition of environmental policy	4.53 (1.71)	.788	.233	.224	.303
Clear objectives and long-term environmental plans	4.30 (1.81)	.863	.243	.165	.240
Well-defined environmental responsibilities	4.45 (1.59)	.814	.167	.241	.268
Full-time employees devoted to environmental management	4.06 (1.97)	.810	.170	.199	.110
Natural environment training programs for managers and employees	3.74 (1.58)	.745	.276	.269	.271
Systems for measuring and assessing environmental performance	4.25 (1.69)	.727	.207	.305	.266
Environmental emergency plans	4.50 (1.72)	.712	.137	.391	.205
Environmental criteria in supplier selection	3.64 (1.80)	.650	.404	.250	.143
Periodic elaboration of environmental reports	3.45 (2.00)	.615	.494	.117	.182
Environmental arguments in marketing	3.33 (1.66)	.457	.421	.308	.160
Shipments consolidation	3.82 (1.62)	.132	.617	.251	.303
Selection of cleaner transportation methods	2.26 (1.31)	.245	.665	.189	.078
Recyclable or reusable packaging/containers in logistics	3.97 (1.41)	.091	.620	.464	.093
Ecological materials for primary packaging	3.75 (1.45)	.154	.606	.471	.220
Recuperation and recycling systems	3.79(1.59)	.268	.410	.355	.134
Acquisition of clean technology/equipment	4.02 (1.43)	.212	.574	.115	.412
Sponsoring of environmental events / collaboration with ecological organizations	2.26 (1.46)	.349	.649	.077	.066
Regular voluntary information about environmental management to customers and institutions	3.23 (1.66)	.548	.573	.207	.236
Substitution of polluting and hazardous materials/parts	4.24 (1.39)	.331	.058	.739	.245
Designs focused on reducing resource consumption and waste generation during production and distribution	3.97 (1.39)	.374	.262	.702	.284
Designs focused on reducing resource consumption and waste generation in product usage	3.76 (1.38)	.330	.330	.750	.179
Design for disassembly, reusability and recyclability	3.44 (1.50)	.210	.372	.691	.091
Preference for green products in purchasing	4.70 (1.26)	.241	.256	.604	.303
Responsible disposal of waste and residues (separation and preparation)	5.34 (1.09)	.172	.078	.153	.736
Emission filters and end-of-pipe controls	4.98 (1.29)	.329	.138	.229	.754
Process design focused on reducing energy and natural resources consumption in operations	4.58 (1.29)	.348	.326	.137	.664
Production planning and control focused on reducing waste and optimizing materials exploitation	4.37 (1.23)	.271	.316	.236	.683
Total explained variance: 67.664%. Varimax orthogonal rotation.					

Table 5. Relationships between variables

	1	2	3	4	5	6	7	8	9	10
1. Company Size										
2. Plant Equipment Age	.006 ¹									
3. Internationalization	10.58 ^{2***}	0.272 ²								
4. Chemical Industry	1.11 ²	40.83 ^{2***}	4.175 ^{3**}							
5. Electronic Industry	6.02 ^{2**}	21.30 ^{2***}	1.963 ³	101.620 ^{3***}						
6. Planning and Org. Practices	.211 ^{1***}	.098 ¹	20.01 ^{2***}	14.44 ^{2***}	0.83 ²					
7. Logistics Processes Practices	.229 ^{1***}	-.004 ¹	0.06 ²	0.10 ²	0.32 ²	.000 ¹				
8. Product Design Practices	.167 ^{1**}	-.058 ¹	9.41 ^{2***}	2.07 ²	0.18 ²	.000 ¹	.000 ¹			
9. Internal Production Processes Practices	.024 ¹	-.092 ¹	6.21 ^{2**}	0.10 ²	0.32 ²	.000 ¹	.000 ¹	.000 ¹		
10. Cultural Manuf. Proactivity	.194 ^{1***}	.041 ¹	26.10 ^{2***}	8.32 ^{2***}	2.69 ²	.307 ^{1***}	.179 ^{1**}	.212 ^{1***}	.420 ^{1***}	
11. Technical Manuf. Proactivity	.256 ^{1***}	-.206 ^{1***}	4.78 ^{2**}	32.735 ^{2***}	29.74 ^{2***}	.052 ¹	.278 ^{1***}	.188 ^{1**}	.039 ¹	.000 ¹

¹ Pearson correlation ² ANOVA F-value ³ Pearson Chi-square
*** p < 0.01 ** p < 0.05 * p < 0.10

Table 6. Relationships between environmental proactivity dimensions and manufacturing proactivity dimensions, multiple regression analysis

	Model 1				Model 2			
	Planning and Organization	Logistics Processes	Product Design	Internal Production Processes	Planning and Organization	Logistics Processes	Product Design	Internal Production Processes
Constant	-.728 *** (.255)	-.099 (.274)	-.056 (.270)	.256 (.274)	-.672 *** (.253)	-.035 (.261)	-.017 (.266)	.387 (.255)
Company Size	.027 ** (.012)	.041 *** (.013)	.023 * (.012)	-.001 (.013)	.021 * (.012)	.026 ** (.012)	.014 (.013)	-.011 (.012)
Plant Equipment Age	-.018 (.088)	-.006 (.095)	-.150 (.094)	-.140 (.095)	.000 (.088)	.031 (.091)	-.126 (.092)	-.108 (.088)
Internationalization	.435 *** (.152)	-.171 (.163)	.364 ** (.161)	.441 *** (.164)	.292 * (.160)	-.412 ** (.166)	.210 (.169)	.160 (.162)
Chemical Industry	.735 *** (.234)	.067 (.251)	.275 (.248)	-.155 (.252)	.744 *** (.237)	.229 (.245)	.384 (.250)	-.240 (.239)
Electronic Industry	.263 (.212)	.054 (.228)	-.038 (.225)	-.308 (.228)	.292 (.210)	.057 (.217)	-.038 (.221)	-.217 (.212)
Cultural Manuf. Proactivity	-	-	-	-	.177 ** (.073)	.198 *** (.076)	.123 (.077)	.418 *** (.074)
Technical Manuf. Proactivity	-	-	-	-	.076 (.078)	.310 *** (.080)	.205 ** (.082)	.020 (.078)
R ²	.182	.058	.084	.054	.212	.160	.127	.200
F	7.942 ***	2.194 *	3.283 ***	2.050 *	6.770 ***	4.785 ***	3.668 ***	6.283 ***
ΔF					3.322 **	10.667 ***	4.324 **	16.003 ***

*** p < 0.01

** p < 0.05

* p < 0.10

Standard errors in brackets