Working Paper 99-18
Business Economics Series 5
February 1999

Departamento de Economía de la Empresa
Universidad Carlos III de Madrid
Calle Madrid, 126
28903 Getafe (Spain)
Fax (341) 6249608

AN INTEGRATED TYPOLOGY OF GREEN MANUFACTURING PROFILES

María José Álvarez* and Jaime Rivera**

Abstract

This article proposes a typology to classify the Environmental Operations Strategies that the European Companies develop in order to adapt themselves to the requests of their green stakeholders. First, main research lines in Environmental Operations Management are analyzed; second, a typology based on the coherency of different variables that have been considered separately by other authors is presented and validated for a sample of 3051 European manufacturing companies. The results show that European manufacturers have not achieved yet similar levels of integration of the environmental concern into all managerial functions with the aim of reaching a sustainable balance between economic and ecological performance of the firm. Consequently, conventional typologies looking at different environmental criteria in a piecemeal fashion seem to be no longer valid for explanatory and/or decision making purposes.

Keywords: Accounting/operations, Environmental issues, Empirical research, International Issues, Operations Strategy

*Universidad Carlos III de Madrid. Dept. Economía de la Empresa, C/ Madrid, 126, 28903 Getafe (Madrid). E-mail:catinaag@eco.uc3m.es, Phone: (+34)91-624-9643, Fax: (+34)91-624-9607.

** Universidad Carlos III de Madrid. Dept. Economía de la Empresa, C/ Madrid, 126, 28903 Getafe (Madrid). E-mail:jrivera@emp.uc3m.es, Phone: (+34)91-624-9618, Fax: (+34)91-624-9607.

-Introduction: The environmental challenge and its impact on Operations Management

Due to the increasing worldwide awareness of the environmental degradation, all levels of society are becoming more involved in environmental issues (Ulhoi, et al. 1993). This environmental concern is shown in an increasing competitive pressure on the firms that force them to improve their environmental performance and to modify the formulation of their strategies (Azzone et al. 1997). The literature proposes that one perspective that offers a basis for exploring the linkage between environmental excellence and performance of firms is manufacturing strategy (Porter and Van der Linde, 1995), since manufacturing strategy should be linked interactively to social and regulatory issues and, in particular, to environmental issues (Klassen 1993). Gupta (1995:34) reinforces this reasoning when he points out that "environmental protection and green consumerism are coming to bear on decision making in operations management system as part of an environmental management system".

When we analyze the strategies used by companies to adapt themselves to the environmental demands we find that literature shows that there are several typologies referring to environmental management strategies (EMS), although just a few of them deal specifically with operations management strategies. Thus, we find a typology based on three categories of environmental management: crisis-oriented, cost-oriented, and enlightened (Petulla, 1987). The firms with crisis-oriented management handle environmental conflicts on a "fire-fighting" basis. These firms have no environmental policy strategy for compliance with laws and regulations and have no separate environmental unit in the firm. The firms with cost-oriented management accept environmental regulations as a cost of doing business, and make efforts to comply with them as efficiently as possible. The firms with enlightened management have strong corporate support to go beyond regulatory compliance.

Another typology refers to corporate environmental management programs, and is the one suggested by Hunt and Auster (1990), which identifies a continuum of five development stages of environmental management programs. The continuum consists of: i)The "beginner", who provides no protection from environmental risks; ii) The "fire-fighter", who

provides minimal protection; iii) The "concerned citizen", who provides moderate protection; iv) The "pragmatist", who provides comprehensive protection and; v) the "pro-activist", who provides maximum protection

One of the few typologies dealing with the integration of environmental issues with the operations strategy of a company (Van Wassenhove and Corbett, 1991), identifies three possible strategies With this typology, a "follower" strategy involves complying with all legal requirements; a "market-oriented" strategy is driven by the market conditions that the environment is subordinated to, but supports the fulfilling of the business strategy; an "environmentally oriented" strategy is one in which the environment is seen as a key factor and is fully integrated with the business strategy[1].

On the other hand, since literature shows that the Operations Functional Area is responsible for obtaining products with a quality and quantity criteria expected by the organization as well as controlling working habits, the use of resources, the emission and flow of dangerous materials, it is easily assumable that operations managers should be directly concerned by the incidence of environmental issues in their responsibilities (Gupta and Sharma, 1996).

As a matter of fact, the relationship between EOS and corporate performance has called the attention in the last twenty years, although the actual decade has seen an increasing number of empirical papers published[2].A similar situation can be observed in relation with, on the one side, the empirical contrast with the corporate results of the environmental strategies, and on the other, the relation between these links and the disclosure of environmental information. These facts have led Russo and Fouts (1997:534) to point out that the economic impact of environmental performance is a specific social issue that has provoked a very public debate and many works that appeared to be empirically contrasted have returned different verdicts.

Nevertheless, due to the emerging nature of the environment as a strategic issue, work has only begun to validate empirically the different typologies as well as the main research lines

[1] Another interesting typology is the one proposed by Rondinelly and Vastag (1996).

[2] See for instance Hayes and Upton (1998), Hum and Leow (1996),and Miller and Cardinal (1994) among others.

that study the linkages between operations management and the environment challenge[3]. Thus, we find that conventional typologies, as well as the literature referred to green management operations, present some empirical emptiness as a consequence of the use of small samples restricted to an industrial sector, or to a specific geographical area or country. At the same time their theoretical frameworks do not always include the complex organizational dynamics that take part in the development of the companies' EOS.

Consequently, while these conceptual efforts have been essential, there has been a dearth of conceptual and empirical studies on how organizations are responding to this new strategic issue. A thorough revision of both academic and professional literature evidences that the breaches previously mentioned are bigger when the scenery of the European Operations Management Strategies is considered. Therefore, the main purpose of our article is to present a typology that integrates and complements typologies and research lines related to green operations management. The leading motivation is that our results can be used as a first empirical validation in different countries and sectors, so this tentative typology can be used as a starting point for the further elaboration of explanatory typologies about European EOS.

The article begins with a discussion of the traditional theory and the conceptual propositions supporting our hypotheses. Then, we examine the methodological approach and the main features of the sample, to continue with the analysis of the results. The objective of presenting and validating the traditional investigation lines in EOS is that our proposal tries to integrate valid contributions and to complement the loopholes found in the antecedents of our proposal.

1.-The state of the art

Along this decade the increasing environmental interest shown by both practitioners and academics has evolved into an increasing number of publications, which suggest that environmental concern is much larger in the 90's than in the previous decade (Newman y

[3]See for instance, Angell (1993), Goodland et al. (1992), Shrivastava (1995) and Judge and Douglas (1998), among others.

Hanna, 1996). Research articles regarding on this can be classified into two main research lines. The first one deals with the success of EOS, as measured by the improvement of corporate results and the diminishing of environmental impact. Following this way of thinking, Gupta (1995: 42) indicates that *"the operations function of a company encounters environmental protection issues directly because it is the main source of operating emissions and thus, environmental management programs and policies should be carefully developed to strengthen its operations strategy"*.

Reinforcing the above mentioned importance, the McKinsey report of 1991 highlights that the environmental concern should be reflected in the EOS by effectively integrating the principles of environmental management into the process of decision making, which leads to the conversion of raw materials into usable products (Gupta y Sharma, 1996: 40). Nevertheless, the above mentioned report also notes that more than 400 worldwide senior executives from various industries believe that corporations only react when the moment arrives but not earlier, either to show approval with the new regulations, or to prevent negative incidents and crisis. Only 13% of the executives indicated that environmental objectives were included in their corporate strategy[4].

Furthermore, a growing body of literature is focused on how companies should manage environmental issues. These articles, such as those by Azzone and Bertele (1994), Azzone et al. (1997), Azzone and Noci (1998), Gray (1990), Noci (1995), Shrivastava (1995), Walley and Whitehead (1994), Welford and Gouldson (1993) or Welford (1993), analyze: i) feasible EOS available to operations managers and describe how growing environmental concern impacts on the process of strategy formation, and ii) general approaches aimed at supporting managers in the assessment of a company's environmental performance.

Therefore, considering the controversy of this topic, which on the one side emphasizes the importance of the EOS, but on the other, indicates its scarce impact on corporate performance, we suggest the following hypothesis:

H1 There is a positive relation between the level of EOS and the level of the

[4] Cited by Newman and Hanna (1996: 70)

expected benefits in costs, competitiveness, and company image.

The second research line hints at a relation between the information systems and the operations management system. Since an organization consumes society's resources that can find alternatives uses elsewhere, society evaluates the usefulness and legitimacy of the organization's activities (Parsons, 1956). Greeno and Robinson (1992: 223) call our attention to the point that "*demands on companies to measure, document and disclose information about environmental performance will become more invasive. In the same way that public companies are measured by their financial results, environmental performance will increasingly become a critical factor to scrutinize*". The demanded information is provided by different types of reports. For instance, Article 5 of EMAS[5] states that the minimum contents of a simplified annual statement are a summary of figures on environmental aspects of the company's site and, where appropriate, any significant changes since the previous statement. The process of Corporate Social Reporting (CSR) consist of "communicating the social and environmental effects of organization's economic actions to particular interest groups within society and to society at large" (Gray et al (1987). Researchers working in this area argue that environmental pro-activity and managerial coherence should be accomplished by CSR models that incorporate similar levels of pro-activity (Adams et al., 1998). Accordingly, Tilt (1997, 369) states that the development of the Corporate Environmental Strategy (CES) by companies generally provides the statement of the company's objectives against which performance can be measured. Stakeholders play an important role in setting the series of objectives or targets that address the organization's overall strategy for dealing with the environment, which would be used as a basis for performance measurement and reporting (Greeno and Robinson, 1992; Gray et al. 1993). The results of the empirical articles are not conclusive, partly due to the area of analysis chosen by each one of them. Wood and Jones (1995) attributed the inconsistent statistical findings on the relationship between corporate social performance and economic performance to "stakeholder mismatching", or comparing the economic outcome desired by one set of stakeholders (e.g., shareholders) to corporate actions desired by another set of

[5] EMAS stands for Eco-Management and Audit Scheme.

stakeholders (e.g., environmental activists).

Taking into account these theoretical precedents, we propose the following research hypothesis:

H2: There is a positive relation between the level of EOS and the environmental information supplied by the companies to their stakeholders.

2.- The Green Spider's Web: our proposal for classifying Green Operations Management

Quite recently, several authors[6] have given support to a previous argument by Kleiner (1991), which stated that: *"a company wanting to be green should address three fundamental questions pertaining to operations: product planning (i.e., new products design, packaging, design for environmentability), pollution-preventing programs (how to reduce waste at the source, green engineering) and disclosure policy (i.e., how much open disclosure of environmental activities should firm supports, what kind of corporate social reporting systems do the companies provide their stakeholder with?)*[7]". These latest articles note that the introduction of an EOS is a very complex issue, since it presents a multi-dimensional impact on performance and often induces a significant modification in operations management procedures; thus, environmental management practices require the integration of environmental concern into all managerial functions, with the aim of reaching a sustainable balance between economic and ecological performance of the firm. This also implies that manufacturing must expand its traditional external focus on customers and suppliers to include third – party stakeholders such as government agencies and the public.

Therefore, we suggest that the environmental pro-activity of a firm's operations management system should be measured on the basis of how much attention it pays to the three overlapping issues regarding sustainability and environmental excellence that are the appropriate focus of future research on the environmental impact of business activity (Newman and Hanna, 1996: 86), and which represent some of the factors that together

[6] See Azzone and Noci (1998), Florida (1996), Gupta (1995), Hutchinson (1996), North (1992), Roome (1992) and Ulhoi (1995), among others

[7] Cited by Gupta (1995: 43)

serve to encourage industry to respond to the environmental challenge (Welford and Gouldson, 1993:6):

- integration of environmental concern with ongoing business practices;
- understanding the environmental ramifications throughout the entire life cycle of a given product;
- measurement issues (pertaining to environmental impact of products and processes, cost of environmental regulation, financial benefit derived through pro-active treatment of environmental concern, etc).

In the light of the above theoretical proposal, we suggest a typology to classify manufacturing companies that relies upon the following six variables

- Environmental awareness (as a proxy for Corporate Environmental Strategy);
- Environmental Operations Strategy (EOS);
- Environmental Plans
- Environmental Programs;
- Corporate Social Report Practices (as they are related to Open Environmental Disclosure); and
- Expected Benefits.

Combining the above elements, we can identify the basic approaches to the integrated development of the EOS which are followed by manufacturing companies. Figure 1 depicts our typology.

INSERT FIGURE 1 ABOUT HERE.

The six variables are represented by six axis, which are clockwise from A to E. For illustrative purposes, the concentric hexagons in the figure represent three possible levels of the proactivity of the firm's environmental operations management system

Integration between Corporate Environmental Strategy and Environmental Operations

Strategy (A+B), or the integration of environmental concern with ongoing business practices.

As long as ten years ago, Greeno (1989) realized that world-class companies were incorporating an environmental, health, and safety perspective into their strategic planning as well as their daily operations-management decisions in order to ensure that their operations were not only be in compliance with legal requirements but also be managed in an environmentally sound and responsible manner[8]. His message, has been be reformulated by Sarkis and Rasheed (1995: 22) as the needing of environmental issues to be explicitly incorporated into the mission and objectives of the firm as well as in the analysis of external opportunities and threats, -corporate environmental strategy CES, (A); thereby, environmental objectives should be built into the plans for each of the functional areas, including operations (B). Newman and Hanna (1996) also provide an excellent support for this argument.

Integration between EOS and Environmental Plans and Programs (B+C1+C2)), or understanding the environmental ramifications throughout the entire life cycle of a given product

Sarkis and Rasheed (1995:17) have described environmentally conscious manufacturing as an integrated process which involves planning, developing, and implementing manufacturing processes and technologies that minimize or eliminate hazardous waste and reduce scrap. The starting point for such process is the Corporate Environmental Strategy (CES), that specifies the products and markets the company wishes to compete in, along with an indication of whether the company will pursue a particular orientation to cost leadership, product differentiation, competitive advantage, etc. (North, 1992). This CES guides the design of the EOS and different environmental plans and programs are developed to support it (Van Wassenhove and Corbett, 1991), and to help the operations managers to develop a distinctive competence and obtain a competitive advantage.

The task for environmental operations management, i.e., the implementation of the EOS,

[8] Cited by Gupta (1995:40)

seems simple. Gupta and Sharma (1996: 41) have described it as the answer to the question of how can a firm organize its production systems to enhance resource productivity by adopting a competitive environmental approach. It consists of two stages. The first one comprises the development of several plans for the different functional areas, i.e., procurement, R&D, manufacturing, logistics, recovering for recycling, and destruction. It is supported by strategic decisions (e.g. product planning and process selection), as well as tactical decisions (production planning and scheduling, inventory management). The second stage is devoted to the translation of plans into detailed programs and projects, such as the purchase of inputs, air and water pollution control, waste disposal operations, new pollution control technology, etc. These programs are directly related to what Sarkis and Rasheed (1995) have defined as the three Rs of environmentally conscious manufacturing: reduce, remanufacture, and reuse/recycle. These authors call our attention to the point that implementing these programs and projects is usually the most critical step in ensuring success, since it includes all activities and tasks required to take the EOS from design to an actual working system; this means that plans and programs cannot be formulated and implemented in a piecemeal fashion.

Integration between Plans and Programs and Corporate Social Reporting (CSR) (C1+C2+D), or measurement issues (pertaining to environmental impact of products and processes, cost of environmental regulation, financial benefit derived through proactive treatment of environmental concern, etc).

Hutchinson (1992) and Welford and Gouldson (1993: 7) note that an increasing number of executives acknowledge that economic activity affects the environment, and their values force them to integrate concern for economic growth with care for the environment. As a result, these corporations are better able to meet the needs of all their stakeholders, who are placing increasing pressure on the environmental performance of the company. Also, Post and Altman (1992), following a similar trend, have argued that environmental issues are more systematic than other social issues and affect a broader constellation of organizational functions. This systematic approach is, as a matter of fact, the leit motiv of the recently developed ISO 14.000 (Tibor and Feldman, 1996). This international certification program

seeks to determine whether a corporation's environmental policies ensure responsible environmental behavior through effective environmental management plans and programs. Any company wishing to obtain a certification of its environmental management system must formulate environmental policies, i.e., it will have to make explicit decisions (plans and programs) about how it will deal with environmental threats and opportunities (Rondinelli and Vastag, 1996:110). Here, the auditing process is important for a number of reasons, in spite of the fact that it is often neglected (Sarkis and Rasheed, 1995:22). Clearly, it will help identify whether the decisions made are meeting the expectations in terms of various environmental performance measures. Moreover, Klassen (1983:86) suggests that production management can improve accountability by using standardized procedures, and individual concern will not be inadvertently overlooked. In addition, if community or legal accountability is required at a later time, a clearly traceable course of action can be demonstrated. The environmental audits can likewise be structured to provide the different types of information as it is requested by the different types of stakeholders.

Integration between D and E, or the relationship between the level of EOS and the environmental information supplied by the companies to their stakeholders.
This situation is represented by H2.
Integration between E and A, or the relationship between the level of EOS and the level of the expected benefits in costs, competitiveness, and company image.
This situation is represented by H1.

Summing up, the theoretical proposal that gives support to our typology, which we have termed as *the Green Spider's Web*, adheres to the idea that companies must seek to develop strategies which translate plans and programs into benefits, improving their environmental performance and addressing the environmental demands placed upon them by government and stakeholders. Operations managers may incorporate the increasingly important environmental dimension into the decision-making processes and strategies of the firm; by doing this, they are seeking to reduce costs and exploit the opportunities offered by increased public environmental concern within a dynamic market-place. Integration is the

key concept in environmental strategy, as it is implicitly reflected within the EC's Fifth Environmental Action Program, which implies that a firm must examine every aspect of its environmental performance.

The analogy with the spider's web can be found in the fact that, although most spiders try to build perfect hexagonal webs, there are not two identical spider's webs. Every spider has to face different particular pressures when it is knitting its web, in spite of the fact that spiders as a specie use to face the same general pressures. While it is senseless to force spiders to replicate a unique design of web, it would be meaningless to force companies to develop identical environmental strategies. Already existing typologies consider the threads of the spider's web, but neither the spider's web, nor how it fulfills its objectives.

3.- Empirical research

3.1.- Sample

Our database has been collected and processed from the results of the answers to a postal questionnaire sent in 1997 to an stratified sample of European companies which were selected for developing the European Business Environmental Barometer (EBEB). The sample that we have work with in this study consists of 3051 manufacturing companies, representing 11 European Union countries. 14 Pilot industrial sectors or manufacturing activities were selected: food and beverage, textiles, leather, wood products, paper products, coke and petroleum, chemicals, rubber and plastic products, other non-metallic products, basic metals, machinery and equipment, electrical, transport equipment, and others.

The questionnaires were translated into the official language of each country in the EBEB and the administrators of EBEB were in charge of posting them. The questions were designed so that comparisons could be made among the answers to the different questions. The leading purpose was to propose solutions and specific environmental initiatives for the European Union dominion based upon the conclusions derived from the survey. Questionnaires were sent along the first months of 1997 and were collected about 12 months later. Table 1 summarizes data about the companies under study, classified by country of origin and the industrial sector they belong to.

INSERT TABLE 1 ABOUT HERE

3.2.- Questionnaires

Environmental operations strategy was defined according to 14 items, which were chosen after a review of the literature, and corrected and revised following discussions with managers and business management professors. These items were used to evaluate the corporate actions of the firm related to the environmental management operations (choice Of suppliers by environmental criteria, recovery of the company 's end-of-life products, etc). The responses were graded on a dicotomic scale, where 1= Yes, and 0= No. The alpha Cronbach index, a 0.8063 value, gave the results a high level of reliability.

Environmental plans were evaluated in terms of six items that measured the firms' actions to optimize the environmental production process from an functional perspective (areas of procurement, research development, production, marketing/sales, logistics and recycling). Likewise, redemption actions, as a proxy for *operations programs* associated with the environmental actions concerning waste-water treatment, soil redemption, risk reduction, etc., were also measured according to six items. For both questionnaires, respondents were asked to answer either "1= Yes" or "0= No". The results showed an acceptable degree of reliability with a 0.70 rating on the alpha Cronbach index, and a significant level of Kendall Coefficient of Concordance (W=0.2082; Significance 0.0000, and W=0.2692; Significance 0.0000, respectively).

The *Environmental Marketing Strategy* (EMS) was measured according to 6 environmental actions (design considerations, market research, providing consumers with information, etc). The responses were graded on a dicotomic scale, where 1= Yes, and 0= No. The results showed an acceptable degree of reliability with a 0.80 rating on the alpha Cronbach index.

In order to assess the *estimated benefits* of corporate environmental actions (competitiveness, corporate image, cost saving, sales, etc) , we used a questionnaire with 5

scales, where 1= Very negative and 5= Very positive. We got an alpha Cronbach index of o.85, thus meaning a reasonable degree of reliability. Moreover, factorial analysis allowed us to reduce the 12 initial items to 3 types of expected benefits: cost savings, increased competitiveness, and public image as well as legitimacy benefits.

Likert scale was used to evaluate the *degree of environmental awareness*. The company participants were asked to respond by using a scale from 1 to 5, where 1 is Strongly disagree, and 5 is Strongly agree.. The medium-high and a significant level of Kendall Coefficient of Concordance (W= 0.3087, Significance 0.0000) among the European managers of 11 countries demonstrated the robustness of this response.

Corporate Social Reporting Practices were evaluated by considering two items: one for the case where the firm publish a separate environmental report, and the other one for these situations where the firms include environmental information in their annual report. A scale was used where 0 = No, 1= Considering, and 2 = Yes. The results showed an acceptable degree of reliability with a 0.70 rating on the alpha Cronbach index.

Table 2 and 3 summarize the answers to the questions referred to the six variables of our typology, aggregated by country and industrial sector, respectively. We have classified them according to the scoring they got in the Likert scale, so that three categories have been considered: high, medium and low.

INSERT TABLES 2 AND 3 ABOUT HERE

4.-Analysis and discussion of results

H1 Is there a positive relation between the level of EOS and the level of the expected benefits in costs, competitiveness, and company image?

The validity of our EOS measure was evaluated before the research results were analyzed.

The internal consistency of the measure for the EOS construct is assessed by a test of one-dimensionality using a common factors model with oblique rotation, and by a standardized Cronbach reliability statistic (Bagozzi 1980).

Convergent and discriminant validity were evaluated using a multitraid method (MM) correlation matrix (Campbell and Fiske, 1959). Convergent validity was determined by whether the correlations between measures of the similar constructs were greater than zero, significant and "sufficiently large") (Campbell Fiske criterion 1) and by the capacity of the construct measure to obtain similar results among different groups (Kerlinger, 1975) or countries, in this case.

For the total sample, the correlation between EOS and EMS was 0.5386, and significant at the $p<0.000$ level. On the other hand, the correlation with *environmental programs* was 0.0732 ($p<0.000$ level), thus meaning that the EOS construct is closer to the concept of a business environmental strategy than to detailed reactive activities.

Once the identity of EOS was validated as representative of the Environmental approaches followed by European companies, we proceed to test H1. Results are shown in Table 4.

INSERT TABLE 4 ABOUT HERE

The significant, but low, association index, give support to the idea that European managers believe that there is a stronger relationship between legitimacy and public image relate benefits, on one hand, and EOS, on the other hand, than between competitiveness and cost savings associated benefits and EOS. Moreover, it provides support to H1, i.e., *there is a positive relation between the level of EOS and the level of the expected benefits in costs, competitiveness, and company image.* It can be expected that due to legitimacy issues, companies do provide much more information about their environmental activities and improvements. So far, we have been able to provide empirical evidence of the proactivity level of the companies in our study.

H2 Is there a positive relation between the level of EOS and the environmental information supplied by the companies to their stakeholders?

Table 5 summarizes the results of the correlation analysis.

INSERT TABLE 5 ABOUT HERE

The association indexes are relatively low, but highly significant. Thereby, these results give support to the intuition that European firms do integrate proactive EOS with higher levels of open disclosure. So far, we have gathered empirical support for the hypothesis that *there is a positive relation between the level of EOS and the environmental information supplied by the companies to their stakeholders.* This means that we have been able to provide empirical evidence supporting the internal coherence and rationality of the analyzed companies

Next step in our empirical study has been to depict the Profiles of the European companies according to the set of scorings they got in Table 2 and 3, respectively. Figures 2 and 3 illustrate our findings.

INSERT FIGURES 2 AND 3 ABOUT HERE

Figure 2 shows 11 completely different Profiles, none of which is shaped like the ideal hexagonal profile we were looking for[9]. This means that it is not possible to characterize the European countries as more or less environmental proactive, since they have got so much different "spider's webs", thus implying different patterns of environmental integration and coherence among countries. In spite of these divergence, it is possible to appreciate some similarities in the shapes of the analyzed countries, meaning that there is some homogeneity among them, i.e., these spiders belong to a similar specie, with the solely exceptions of Norway, Germany and Spain. These three countries have developed some of the environmental variables quicker than others, allowing strange polygonal shapes to appear.

[9] We used the Statgraphics program for this purpose.

The remaining countries seem to be following a coordinated medium level of proactivity, where Portugal appears as the slower spider.

Figure 3 illustrates the spider's webs corresponding to the 14 industrial sectors in the sample. First at all, we appreciate that most sectors enjoy a medium level of environmental proactivity , wherein sector 3, - leather and leather products, seems to walk several steps behind their colleagues. Second, as it could have been predicted, sector 6, -coke, refined petroleum and nuclear fuel, a highly polluting sector, has gone several steps further than the remaining industries. However, its development has not been balanced, as the strange shape of its profile has revealed. This finding is consistent with available empirical evidence: companies in this sector has paid much more attention to remediating actions than to develop long term EOS, on the one hand, while, on the other hand, the expected benefits linked to the development of corporate environmental strategies (mostly legitimacy benefits) are immense.

It is also worthwhile noting that, except by sector 6, all sectors share a similar polygonal shape, which can be explained by a possible lack of sectorial effects and the presence of equilibrium among the different functional initiatives of the firms and its later translation into environmental operations programs.

5.-Implications and conclusions

We have provided empirical evidence to support the fact that European manufacturing firms are indeed moving towards greater environmental awareness and responsibility, and that, compared to other functional areas, environmental concern have greater relevance for manufacturing activity. It has also been shown that these companies' Environmental Operations Strategies (EOS) are an integral part of their Corporate Environmental Strategy (CES) and organizational philosophy, which permeate every functional area and activity within a firm. Another interesting result from our empirical study is that those companies that face the environmental challenge with an integrated and rational-inspired focus, are the ones that show higher pro-activity levels along the full stages of the Life Cycle of their product mix, although there is not a single country nor a solely industrial sector, which a

remarkable big hexagonal spider's web, i.e., we have not found a very integrated, balanced and proactive country, nor industrial sector fulfilling these characteristics. This analysis demonstrates that despite the complexity of environmental strategic issues, management, and operations management related literature often deals with these issues in a simplistic manner, as demonstrated in the restraints linked to the application of the conventional typologies.

In practice, our suggested framework can be used to analyze whether the adopted pattern of environmental behavior should be changed in order to achieve higher levels of both internal and external integration and rationality. Moreover, companies in a given country may assess their relative position in the suggested typology and re-adjust their pro-activity levels in terms of the different variables. In accordance with the main characteristics of the natural environment where the companies operate, operations managers must first identify the detailed Programs (variable C2) and Plans (variable C1) to be tried, and only then, select the Operations-related strategic option (variable B) which is both sustainable in the long term (variables D and E) and consistent with the corporate environmental strategy and managerial orientation (variable A). As a matter of fact, this typology may be used as a decision tool for the companies, helping them i) to not underestimate the business opportunities offered by the growing worldwide concern for environmental protection; and ii) to not underestimate or overestimate the costs and constraints created by legal and market demands for environmental management. On the other hand, not only benchmarking initiatives are favored by the analysis of the suggested typology, but also political and economic initiatives can use it as a starting point.

Given the different Profiles shown by the European companies in the sample, our study shows the likely inadequacy of embracing the growing movement towards adopting international standards; our results reinforce previous comments by Vastag et al (1996: 194), who defend that typologies seeking to impose universal principles of sustainable development and environmental management often push corporations to adopt environmental management approaches that may be either inappropriate or imprudent for their circumstances.

We will imagine, for illustrative purposes, the case of a Spanish manufacturer of nuclear

fuel, provided there is such a manufacturer in Spain. According to its country of origin green profile, this company will show a high proactivity figure regarding remediating actions, i.e., environmental plans, together with a relativity low proactivity level referred to open disclosure policies. When the industrial sector perspective is chosen, this firm will be again characterized by its emphasizing remediating actions, but for its huge concern for legitimacy benefits as well. By combining its two polygonal shapes, this firm could realize that by increasing its corporate social reporting practices, for instance, an improvement in its legitimacy benefits could be faster achieved than by putting efforts and money in developing environmental plans. The company needs to improve its operations programs however and reinforce its EOS, thus meaning that quick answers are not the ones providing the firm with a sustainable competitiveness.

Every study is limited by the design of the questionnaire and / or survey instrument, and this study is not an exception. The first pitfall of this article resides in the fact that all data used have been provided by the managers who answered the questionnaire, meaning that some possible biases cannot be avoided by any filter. Thus, the generalization that emerges from our study is limited by the sampling frame used. A second limitation has to do with the fact that, like other studies in organizational science, our data are cross-sectional. We hope that future research in the form of longitudinal studies and additional surveys will refine and extend our understanding of the development of the organizational capability of integrating the different dimensions of environmental issues into the strategic planning process. The third shortcoming is related to the lack of data from Eastern Europe, Turkey, Israel and other Mediterranean countries. A logical extension of this research would be to test the framework using a data set that comprises data from countries belonging to developed and non-developed market economies.

The above mentioned caveats provide several issues for future research work, since our findings are quite robust and the results, very provocative; what we have shown is that every aspect of an organization's environmental impact needs to be recognized by a holistic corporate environmental strategy (CES). The basic conclusions of this article concerning an

alternative typology of environmental operations strategies and management systems developed by European manufacturing companies are drawn upon the logic of not improving the environmental impact of one part of a firm's activities if this simply means shifting it to another division. As Welford and Gouldson (1993: 13) state, *"Real environmental improvement should be a Pareto improvement, that is, an improvement with no offsetting deterioration elsewhere"*. Although these conclusions require further elaboration, they present an interesting theoretical and empirical agenda.

References:

Adams, C. A., Hill, W-Y, Roberts, C. B., (1998) "Corporate Social Reporting practices in Western Europe: legitimating corporate behavior?", British Accounting Review, 30, 1-21.

Angell, L. (1993) "Environmental management as a competitive priority", *Proceedings of the National Meeting,* Decision Sciences Institute.

Azzone, G., Bertelé, U. (1994) "Exploiting green strategies for competitive advantage", Long Range Planning, December

Azzone, G., Bianchi, R., Mauri, R., and Noci, G. (1997), "Defining operating environmental strategies: programmes and plans within Italian industries", Environmental Management and Health, Vol. 8, Part 1, 1-15.

Azzone, G., Noci, G. (1995) "How to design a performance measurement system for supporting pro-active green strategies", The Workshop on Greening of management, EIASM, Brussels, 12th-13th January.

Bagozzi, R. (1980) *Casual Models*, Wiley, New York

Campbell, D. and Fiske, (1959) "Convergent and discriminant validity by the multitrait-multimethod matrix", Psychological Bulletin, May, pp.-81-105.

Florida, R. (1996) "Lean and green: The move to environmentally conscious manufacturing", California Management Review, Vol. 39, N° 1, 80- 106

Goodland, R., Daly, H., Serafy, S. E., and Droste, B. van (Eds) (1992) *Environmentally Sustainable Development: Building on Brundtland,* UNESCO, Paris.

Gray, R. (1990) "Accounting and Environmentalism: an exploration of the challenge of gently accountability, transparency and sustainability", EIASM Workshop on Green

Accounting.

Gray, R. Owen, D., and Maunders, K. (1987) *Corporate Social Reporting*, Prentice-Hall, Englewood Cliffs, NJ.

Gray, R. H., Bebbington, J., and Walters, D. (1993) *Accounting for the Environment,* London, Paul Chapman Publishers.

Greeno, F. L. (1989) *Environmental Management: The Challenges for Business Leadership,* Center for Environmental Assurance, Arthur D. little, New York, NY.

Greeno, J.L., and Robinson, S. N: (1992) "Rethinking Corporate Environmental management", The Columbia Journal of World Business, Fall-Winter, pp. 222-232.

Gupta, M. (1995) Environmental management and its impact on the operations function, International Journal of Production and Operations Management, Vol. 15, n 8, pp. 34-51

Gupta, M., and Sharma, K. (1996) "Environmental operations management: an opportunity for improvement", Production and Inventory Management Journal, 3rd Qter, 40-46.

Hayes, R. H. and Upton, D.M. (1998) "Operations-Based Strategy", California Management Review, Vol. 40, N° 4, pp. 8-25.

Heaton, G., Repetto, R., and Sobin, S. (1991) *Transforming technology: An agenda for environmental sustainable growth in the 21st century*, World Resource Institute, Washington, D. C.

Hum, S. and Leow, L. (1996) Strategic manufacturing effectiveness. An empirical study based on the Hayes-Wheelwright framework", International Journal of Operations and Production Management, Vol. 16, N° 4, pp. 4-18.

Hunt, C. B., and Auster, E. R. (1990) "Proactive Environmental Management: Avoiding the Toxic Trap", Sloan Management Review, 31, N° 2, pp. 7-18.

Hutchinson, C. (1996) "Integrating Environment Policy with Business Strategy", Long range Planning, Vol. 29, N° 1, pp. 11-23.

Judge, W., Q., and Douglas, T., J. (1998) "Performance Implications of incorporating natural environmental issues into the strategic planning process: an empirical assessment", Journal of Management Studies, Vol.35, N° 2., 241-262.

Klassen, R. D. (1993)"The integration of environmental issues into manufacturing: towards an interactive open-systems model". Production and Inventory Management Journal, First

Quarter, 82-88.

Kerlinger, F. (1975) *Foundations of Behavioral Research,* A. Holt International Edition.

Kleiner, A. (1991) "What Does It Mean to Be green", Harvard Business Review, July-August, pp. 38-47.

McKinsey and Company (1991) *The corporate response to the environmental challenge,* McKinsey and Company, Amsterdam

Miller, C.C., and Cardinal, L. B. (1994) "Strategic planning and firm performance: A synthesis of more than two decades of research", Academy of management Journal, Vol. 37, N° 6, pp. 1649-1665.

Newman, W. R., and Hanna, M.D. (1996) "An empirical exploration of the relationship between manufacturing strategy and environmental management" International Journal of Operations and Production Management, Vol. 16, No. 4, pp. 69-87

Noci, G. (1995) "The role of environmental performance in supply chain management", Proceedings of the 2nd International Symposium on Logistics, Nottingham, 11th-12th, July.

North, K. (1992) *Environmental Business Management: An introduction,* Geneva: international labor Organization.

Parsons, T. (1956) "Suggestions for a sociological approach to the theory of organizations", Administrative Science Quarterly, 1, pp. 63-85.

Petulla, J. M. (1987) "Environmental management in industry", Journal of Professional Issues in Engineering, Vol. 113, pp. 167-183.

Porter, M. and Van der Linde, C. (1995) "Towards a new conception of the environment-competitiveness relationship", Journal of economic Perspectives, Vol. 9, N° 4, pp. 97-118.

Post, J. E. and Altman, B. W. (1992) "Models of corporate greening: how corporate social policy and organizational learning inform leading-edge environmental management". In J,. E. Post (ed.) *Research in Corporate Social Performance and Policy,* 13, 3-29, Greenwich, CT: JAI press.

Rondinelli, D. A., and Vastag, G. (1996), International Environmental Standards and Corporate Policies: An integrative framework. California Management Review, Vol. 39, no.1, 106-122.

Roome, N. (1992) "Developing Environmental Management Strategies", Business Strategy

and the Environment, Vol 1., Part 1.

Russo, M.V. and Fouts, P. A. (1997) "A resource based perspective on corporate environmental performance and profitability", Academy of Management Journal, Vol 40, N° 3, pp 534-559

Sarkis, J. and Rasheed, A. (1995), Greening the manufacturing function, Business Horizons, Sept-Oct., 17-27.

Shrivastava P. (1995) "The role of corporations in achieving ecological sustainability", Academy of Management Review, Vol. 20, pp. 930-60.

Smart, B. (1992) *Beyond Compliance,* World Resources Institute, Washington, DC, 1992.

Tibor, T. and Feldman, Y. (1996) *ISO 4000: A guide to the new environmental management standards,* Chicago, Irwin

Tilt, C.A. (1997) "Environmental policies of major companies: Australian evidence", British Accounting Review, 29, 367-394.

Ulhφi, J. P. (1995), Corporate environmental and resource management: In search of a new managerial paradigm. European Journal of Operational Research, 80 (1995), 2-15.

Ulhoi, J. P., and Hildebrandt, S. H. (1993) "Corporate excellence through technology, environmental and quality management", in: Sumanth, D. et al. (Eds), *Productivity and Quality Management Frontiers*, Industrial Engineering and Management Press, Norcross, GA.

Van Wassenhove, L. N., and Corbett, C. (1991) "How green is your manufacturing strategy?, INSEAD R & D, Working paper no. 91/50/TM/SM.

Vastag, G., Kerekes, S., and Rondinelli, D. A.(1996) "Evaluation of corporate environmental management approaches: A framework and application", International Journal of production Economics, 43, 193-211.

Walley, N. and Whitehead, B. (1994) "It's Not Easy Been Green", Harvard Business Review, May-June, pp. 46-52.

Welford, R. (1993) "An integrated systems approach to environmental management: a case study of IBM UK", Business Strategy and the Environment, Vol. 2, N° 3, Autumn.

Welford, R., and Gouldson, A. (1993) *Environmental Management and Business Strategies*, Pitman Publishing, London.

Wood, D. J., and Jones, R. E. (1995) "Stakeholder mismatching: A theoretical problem in empirical research on corporate social performance", International Journal of Organizational Analysis, 3: 229-267.

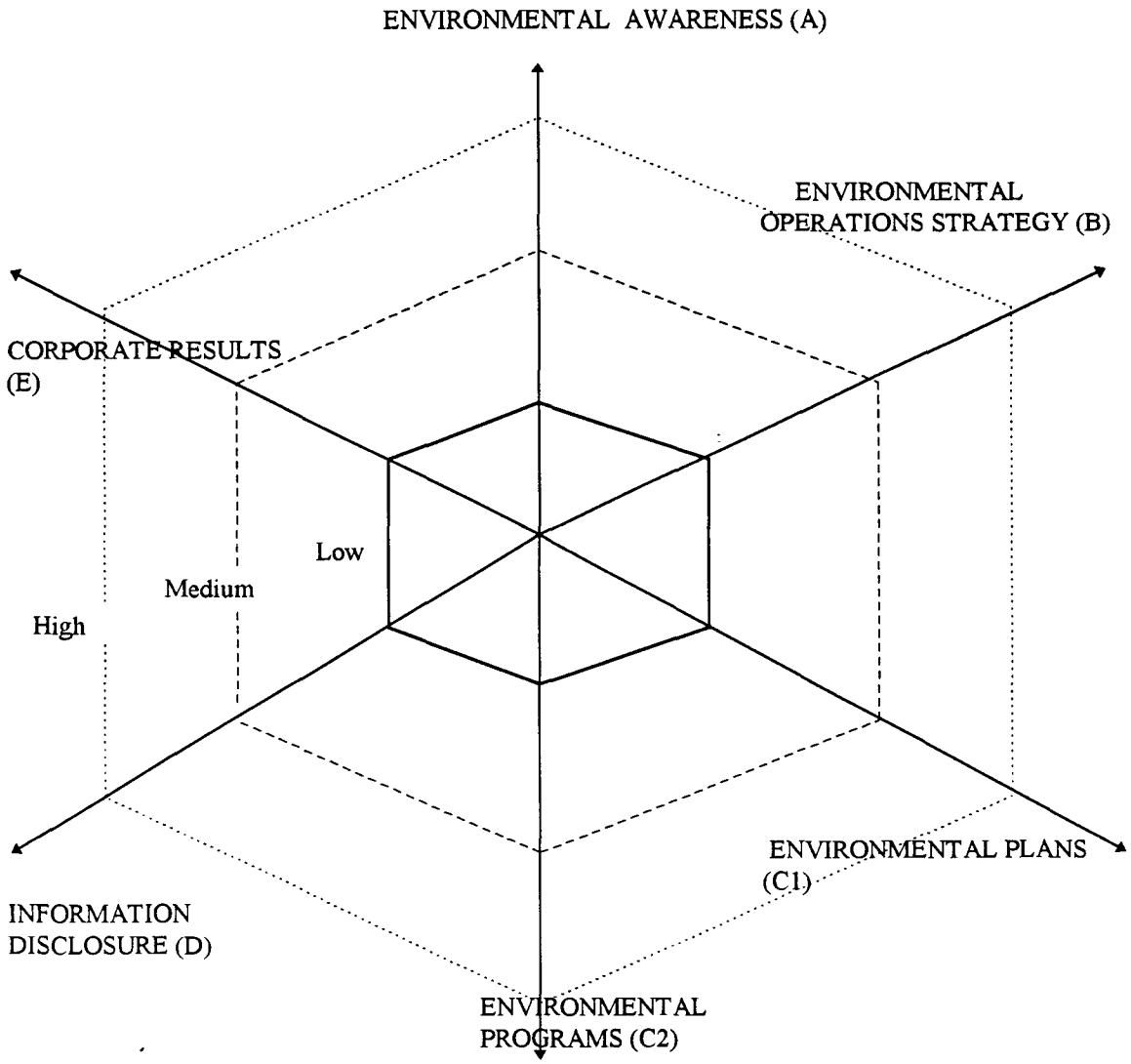


FIGURE 1: The Green Spider's Web

Table 1: Companies under study, classified by country of origin and industrial sector

Country	INDUSTRIAL SECTORS													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Austria	19	14	-	22	11	-	22	-	4	9	28	27	8	23
Belgium	41	49	1	24	11	3	38	31	18	77	19	15	5	28
France	18	9	1	7	11	1	29	16	8	36	24	2	16	13
Italy	12	24	5	9	5	4	11	11	7	19	21	12	2	-
Holland	76	16	3	20	47	1	43	31	9	78	50	4	9	137
Norway	52	20	3	31	50	4	7	10	12	46	45	28	-	-
Portugal	37	64	12	11	10	1	6	13	26	29	10	8	3	-
Spain	14	7	6	-	5	9	11	7	3	17	8	14	6	5
Sweden	24	13	-	32	38	1	13	13	13	131	19	19	11	-
Switzerland	28	11	1	9	19	-	19	14	3	39	32	37	2	12
Germany	20	2	-	2	7	4	40	5	4	13	9	34	14	-

1.- Food, beverage, tobacco
2.- Textiles and textiles products
3.-Leather and leather products
4.- Wood and wood products
5.- Paper products, publishing and printing
6.- Coke, refined petroleum products and nuclear fuel
7.- Chemicals, chemicals products and man-made fibers
8.-Rubber and plastic products
9.- Other non-metallic products
10.- Basic metals and fabricated metal products
11.- Machinery and equipment
12.- Electrical and optical equipment
13.- Transport equipment
14.- Other

Valid cases 2761

Missing cases 290

FIGURE 2: COUNTRY-BASED EUROPEAN GREEN OPERATIONS PROFILES

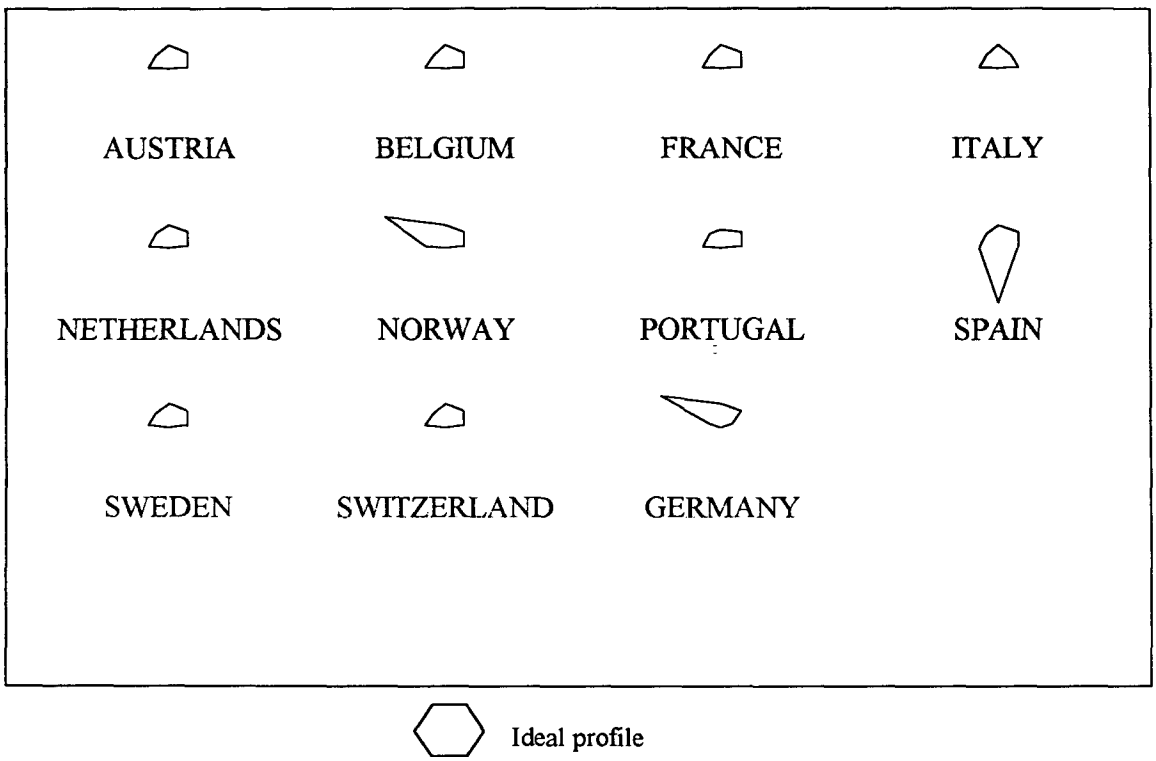
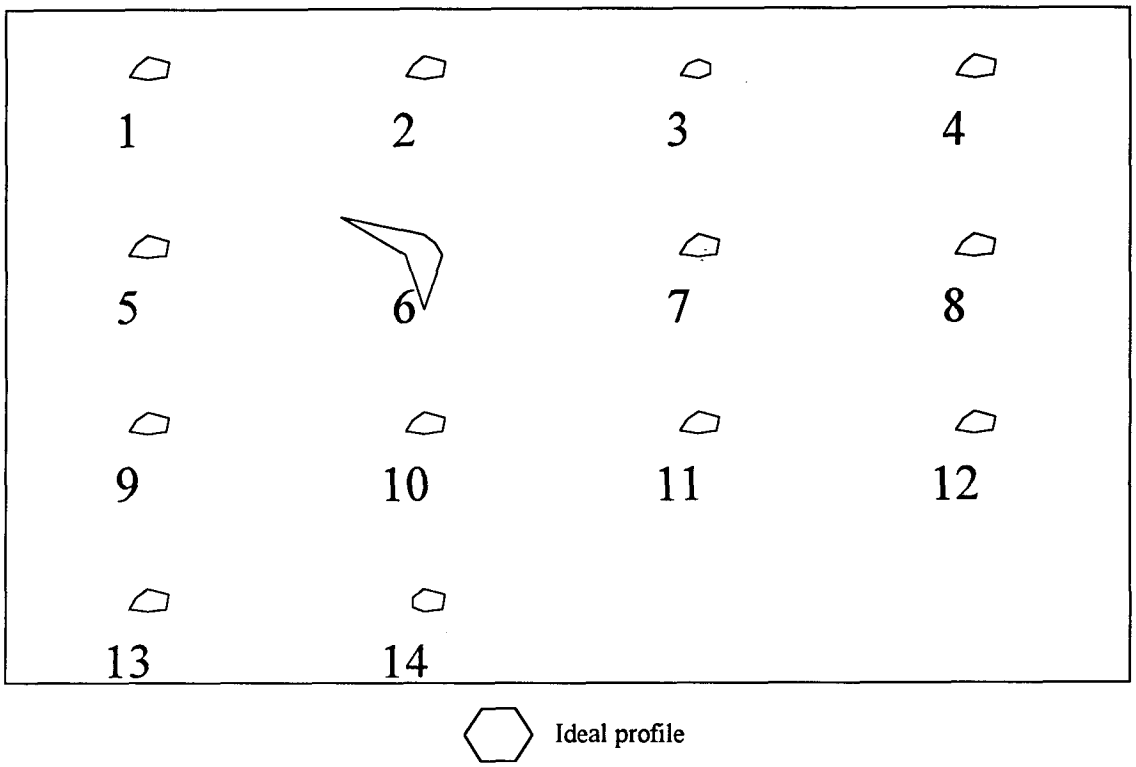


FIGURE 3: EUROPEAN INDUSTRIAL GREEN OPERATIONS PROFILES



1.- Food, beverage, tobacco
2.- Textiles and textiles products
3.-Leather and leather products
4.- Wood and wood products
5.- Paper products, publishing and printing
6.- Coke, refined petroleum products and nuclear fuel
7.- Chemicals, chemicals products and man-made fibers
8.-Rubber and plastic products
9.- Other non-metallic products
10.- Basic metals and fabricated metal products
11.- Machinery and equipment
12.- Electrical and optical equipment
13.- Transport equipment
14.- Others

Table 2: Companies in the sample, classified by country and scorings in the spider's web typology

Variable %	A) Environmental Awareness			B) Environmental Operations Strategy			C1) Environmental Plans			C2) Environmental Programs			E) Expected Benefits			D) Information Disclosure		
COUNTRY	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low
Austria	35.8	22.6	41.6	24.7	55.8	19.5	63.2	30.5	6.3	62.6	31.1	6.3	38.1	56.6	5.3	11.1	22.1	66.8
Belgium	23.1	22.0	54.9	20.0	41.7	38.4	61.4	15.9	22.7	66.0	24.2	9.9	26.9	62.9	10.2	16.2	24.2	59.6
France	9.4	11.0	79.6	13.4	58.6	28.0	37.8	34.4	27.8	51.4	26.3	22.3	35.0	52.5	12.6	11.3	16.7	72.0
Italy	18.8	25.4	55.8	15.1	43.4	41.6	56.7	28.3	15.0	45.3	39.8	14.9	37.9	57.6	4.5	6.6	10.2	83.2
Holland	24.5	33.6	41.9	18.7	59.2	22.1	67.8	28.8	3.5	53.7	37.8	8.4	30.2	58.4	11.4	15.3	31.3	53.4
Norway	44.4	32.9	22.7	23.5	44.2	32.3	56.2	31.8	12.0	50.5	35.9	13.6	31.1	65.2	3.7	21.8	51.3	26.8
Portugal	42.3	15.0	42.7	25.3	51.2	23.5	40.7	47.7	11.7	63.8	25.8	10.4	51.6	42.2	6.2	3.4	10.0	86.6
Spain	29.2	23.9	46.9	57.5	36.3	3.2	58.9	34.8	6.3	55.9	36.9	7.2	60.6	35.8	3.7	8.8	37.2	54.0
Sweden	50.6	24.7	24.7	21.3	46.5	32.2	67.5	28.7	3.9	63.3	30.1	6.6	68.7	28.6	2.7	11.4	25.9	62.7
Switzerland	36.4	26.8	36.8	41.1	46.4	12.5	62.1	27.4	10.5	63.7	29.8	6.5	38.6	54.5	6.9	4.0	24.2	71.8
Germany	31.4	30.8	37.9	29.5	60.2	10.2	80.8	18.0	1.2	12.0	83.8	4.2	53.0	40.4	11.4	34.8	38.4	26.8

Table 3: Companies in the sample, classified by activity sector and scorings in the spider's web typology

Variable %	A) Environmental Awareness			B) Environmental Operations Strategy			C1) Environmental Plans			C2) Environmental Programs			E) Expected Benefits			D) Information Disclosure		
Sector	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low
1	29.6	24.9	45.5	27.2	48.5	24.3	58.0	31.7	10.4	57.3	33.1	9.6	34.5	56.9	8.6	12.3	32.5	55.1
2	30.6	22.7	46.7	13.8	58.0	28.1	55.5	34.4	10.1	64.6	25.6	9.9	36.8	56.8	6.4	7.1	15.1	77.8
3	34.4	21.9	43.8	21.9	56.3	21.9	43.8	43.8	12.5	34.4	43.8	21.9	35.5	45.2	19.4	6.3	18.8	75.0
4	43.1	25.1	31.7	16.5	47.6	36.0	58.4	28.0	13.7	53.8	32.5	13.8	38.1	55.0	6.9	6.7	27.9	65.5
5	32.2	28.5	39.3	26.9	51.9	21.2	66.2	24.4	9.4	60.4	33.3	6.3	38.8	56.7	4.5	17.5	36.4	46.1
6	28.6	17.9	53.6	44.4	48.1	7.4	50.0	39.3	10.7	43.5	47.8	8.7	62.5	37.5	0.0	32.1	57.1	10.7
7	23.8	26.4	49.8	32.3	45.5	22.1	59.7	28.0	12.3	59.9	27.4	12.7	47.2	47.2	5.6	37.3	26.2	36.5
8	35.1	27.2	37.7	31.5	50.0	18.5	66.9	21.2	11.9	56.8	31.5	11.6	39.6	54.2	6.3	9.7	19.3	71.0
9	37.4	23.4	39.3	34.0	43.4	22.6	54.3	35.2	10.5	57.8	34.3	7.8	46.1	51.0	2.9	13.6	30.1	56.3
10	33.6	25.3	41.1	21.0	50.7	28.3	65.7	26.0	8.3	62.2	28.9	8.9	43.1	47.5	9.4	11.5	28.9	59.5
11	32.5	23.4	44.2	18.1	50.8	31.1	52.1	35.0	12.9	54.2	34.0	11.9	29.6	62.1	8.3	9.3	21.8	68.9
12	42.0	24.5	33.5	29.9	47.9	22.2	63.6	28.6	9.6	66.3	27.7	6.0	44.7	47.2	8.2	9.4	28.1	62.5
13	23.7	28.9	47.4	17.3	64.0	18.7	60.8	28.4	10.8	50.0	38.3	11.7	54.2	42.4	3.4	17.3	29.3	53.3
14	22.9	29.4	47.7	26.0	51.2	22.8	66.0	25.1	8.8	52.8	36.4	10.7	36.8	53.8	9.4	12.3	32.1	55.7

1.- Food, beverage, tobacco
2.- Textiles and textiles products
3.-Leather and leather products
4.- Wood and wood products
5.- Paper products, publishing and printing
6.- Coke, refined petroleum products and nuclear fuel
7.- Chemicals, chemicals products and man-made fibers
8.-Rubber and plastic products
9.- Other non-metallic products
10.- Basic metals and fabricated metal products
11.- Machinery and equipment
12.- Electrical and optical equipment
13.- Transport equipment
14.- Other

Table 4: correlation analysis of EOS and expected benefits

	BENPOLIT	BENCOMPT	BENCOSTS
EOS	0.1989 **	0.1624**	0.0910**
* - Signif. LE .05 ** - Signif. LE .01 (2-tailed)			

- **Benlegy:** Benefits linked to legitimacy: It aggregates benefits connected to Corporate Image, Owner's satisfaction, and Top Management Satisfaction.
- **Bencompt**: Competitiveness Benefits: It stands for benefits related to Competitiveness, Market Share, New Market Opportunities, Product Image, and Sales
- **Benecon:** Economic Benefits: It represents those benefits associated to the economics of the company, such as Cost Savings, Long Term Profits, Productivity Increases, and Short Term Benefits.

Table 5: correlation between EOS and open disclosure

	Separate environmental report	Includes environmental information
EOS	0.1666**	0.1824**
* - Signif. LE .05 ** - Signif. LE .01 (2-tailed)		