

Eco-design in innovation driven companies: perception, predictions and the main drivers of integration. The Spanish example

Maria Santolaria ^{a,b,*}, Jordi Oliver-Solà ^{a,c}, Carles M. Gasol ^{a,c}, Tito Morales-Pinzón ^{a,d}, Joan Rieradevall ^{a,e}

^a SosteniPrA (UAB-IRTA-Inèdit), Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona, Bellaterra, Cerdanyola del Valles, 08193-Barcelona, Spain

^b Infonomia Av. Icaria, 205–207, 2-1, 08005 Barcelona, Spain

^c Inèdit Innovació SL, UAB Research Park, Carretera de Cabrils, km2. IRTA, 08348 Cabrils, Barcelona, Spain

^d Facultad de Ciencias Ambientales, Universidad Tecnológica de Pereira (UTP), Colombia

^e Department of Chemical Engineering, School of Engineering, Universitat Autònoma de Barcelona, Bellaterra, Cerdanyola del Valles, 08193-Barcelona, Spain

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ABSTRACT

This study attempts to contribute to the scarce knowledge on how eco-design, and to broad extent sustainability, is connected to innovation driven companies. In particular, this cross sectional research verifies i) perception and knowledge of eco-design of the professionals from innovation driven companies in Spain, ii) specific eco-design strategies towards sustainability that innovation driven companies are integrating in their strategic plans and their application in the supply chain and iii) the companies' future predictions on innovation and eco-design linkage. The methodology of this paper is based on a survey, developed defining measurable proxies for both eco-design and innovation approaches and conducted on 10,000 multidisciplinary professionals from Spanish innovation driven companies. The study shows that sustainability is a cardinal driver for innovation and that responses have specificities regarding company size, activity or respondent position. Innovation and eco-design strategies for the future aim to use materials with a lower environmental impact and to develop new concepts.

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1. Introduction

Environmental factors are increasingly seen by companies as opportunities to drive business efficiencies, stimulate innovation, reduce costs, improve brand positioning and enhance business communications. In addition, the success in addressing these environmental factors provides exciting new terrain for competition and new ways of adding value to core business programmes (Porter, 1991; Porter and van der Linde, 1995; Sinclair-Desgagné, 1999; O'Rafferty, 2008; Lewis and Gertsakis, 2001; Day, 1998). Some research emphasized that companies using an environmental lens are generally more innovative and entrepreneurial than their competitors (Esty and Winston, 2006).

Companies are central to the solution of sustainability problems. The way in which companies innovative exerts a crucial influence

on our wellbeing and the environment in which we live (Kemp and Andersen, 2004).

1.1. Innovation and eco-design

According to the *Advisory Committee on Measuring Innovation in the 21st Century Economy* (2008), innovation is “the design, invention, development, and/or implementation of new or altered products, services, processes, systems, organizational structures, or business models for the purpose of creating new value for customers and financial returns for the firm”. Hence, eco-design, which is defined as “the systematic incorporation of life cycle considerations into the design of products, processes or services” (Tukker et al., 2000), plays a fundamental role in innovation driven companies, adding a sustainable value to the strategy of the firm.

In a broad sense, the literature on sustainability aims to provide a better understanding of the relationship between business and the environment (Loorbach et al., 2009). Looking more closely, existing literature is mainly characterized by sector (Gago and Antolin, 2004; Handfield et al., 1997; Fraj-Andres et al., 2008;

* Corresponding author. Infonomia, Av. Icaria, 205–207, 2-1, 08005 Barcelona, Spain.

E-mail addresses: maria@infonomia.com, maria.santolaria@gmail.com (M. Santolaria).

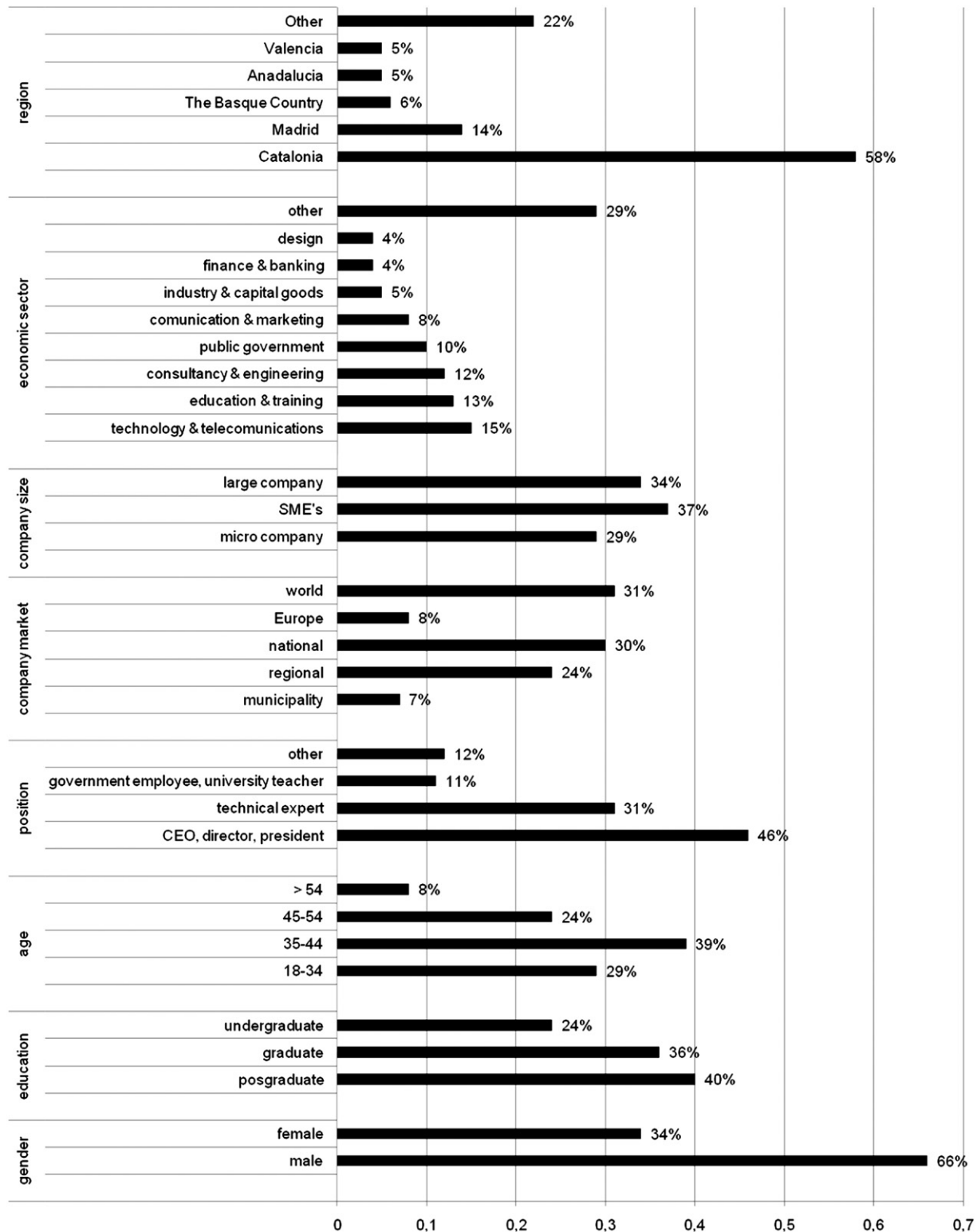


Fig. 1. The personal and company details of respondents.

Ozaki, 2009; Wagner, 2007a, 2007b), company size (van Hemela and Cramer, 2002; Noci and Verganti, 1999; Bos Brouwers, 2009; Rao et al., 2009), geographical area (Smith and Crotty, 2008; Da Silva and Teixeira, 2005), type of business innovation developed (Hellström, 2007), business activity (Cleff and Rennings, 1999) or by willingness of a firm to adopt cleaner technologies (Montalvo,

2003). Therefore, limited interdisciplinary research to date has been based on business, innovation and sustainability.

The aim of this paper is to empirically investigate the cross sectional connection between innovation driven companies and eco-design, given that innovation and sustainability are multidisciplinary concepts. To be more specific, this paper verifies the

perception of innovation driven companies about sustainability and eco-design. This paper also assesses eco-design implementation and integration in the supply chain and determines the drivers and the future of eco-design implementation, according to economic sector, geographical area, position or company size specificities.

From observation of the Europe scenario, some research shows that countries such as Denmark, Germany, the Netherlands, Austria and Sweden are clear front-runners as regards method development, dissemination and education in the field of eco-design (Tukker et al., 2000). However, little research has been carried out in Spanish companies to learn about the implementation, development and future scenarios of eco-design. Furthermore, a standard questionnaire to scan for this information does not exist.

To reach the objectives pursued in this study, the rest of the paper is structured as follows. First, the research methodology, data collection and system of study are described. Second, a result analysis on eco-design perception, predictions and main drivers of integration in Spanish innovation driven companies has been conducted. Finally, we conclude this paper with the main conclusions and a discussion.

2. Material and methods

2.1. Methodology

The overall structure of the questionnaire consisted in three main areas of inquiry:

- I) Perception: drivers, obstacles and environmental, eco-design and innovation attitudes.
- II) Reality: specific eco-design strategies towards sustainability and the application stage in the supply chain.
- III) Future: predictions on eco-design in the innovation framework.

In addition, a general unit covering individual and company profile characteristics was included at the beginning of the questionnaire.

The survey was validated and revised qualitatively by a panel of 30 Spanish senior professionals from the following backgrounds of

expertise: sustainability, innovation, public administration, design and eco-design, and social perception. After their feedback, mostly based on the answer choices, the last version of the questionnaire was conducted. The Appendix summarizes the main survey questions used in the following analysis.

2.1.1. Data collection

Data were collected using a 15-min self-administered structured closed questionnaire. This was preferred to the less structured questionnaire, due to the size of the system of study and to ensure that answers could be added reliably and that comparisons could be made confidently between system subgroups.

2.1.2. Computing program

The computing application used consisted of a PHP programmed website form, which is especially suited for website development and can be embedded into HTML. The interpretation and implementation of the questionnaire was hosted on a server and stored in a script based programming language. The PHP programming language software was linked to a database. The database used specifically for this research was MySQL, a management system for relational databases that allows speed and flexibility in use. Moreover, JavaScript routines were implemented to the questionnaire to ensure the integrity of the answers.

The resulting data was analysed statistically using the STAR tabulation tool, a broad package for professional data processing that has different modules to define, process, view, edit and print tables.

2.1.3. System of study

The chosen system of study for conducting the research was the 10,000 multidisciplinary professionals from innovation driven companies settled in Spain, out of the 20,000 that form Infonomía, the largest innovation network in Spanish.

The data collection was conducted by e-mail between May and June 2007. Each e-mail included a presentation letter with a participation request and a link to the computing application that allowed the participant to begin answering the survey. Finally, a follow-up e-mail reminder was sent out two weeks after the first questionnaire was launched.

In total, 10,032 surveys were sent out, 1256 of which were returned, representing a response rate of 12.52%. From that 1256

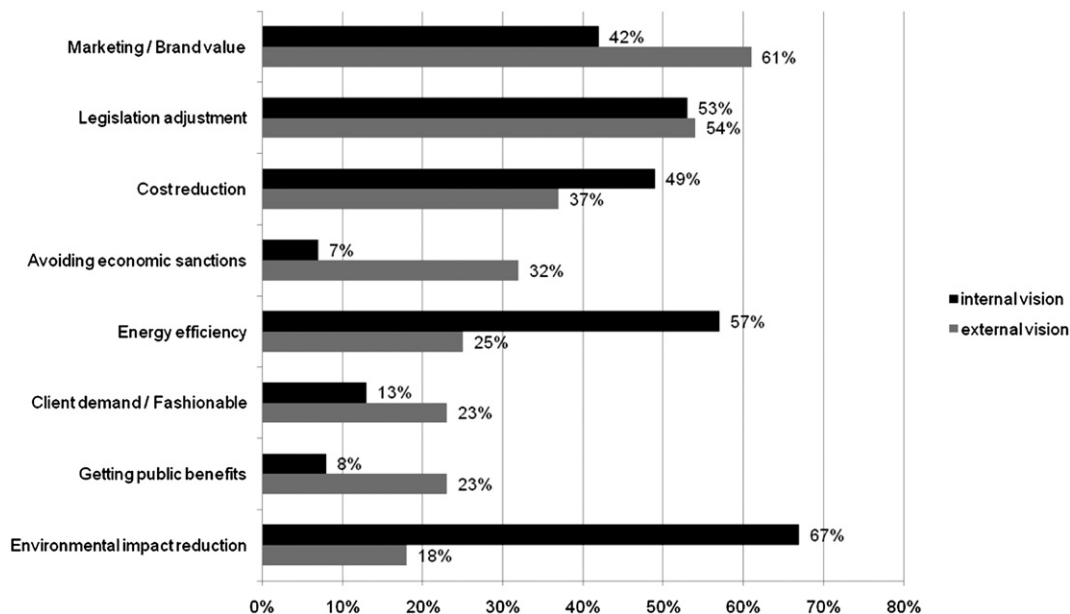


Fig. 2. The Internal and external vision of the determinants that lead to the incorporation of environmental criterion into strategic plans.

Table 1

Determinants for integrating environmental criteria into the strategic plans from the point of view of company size.

	Micro companies(1–10 employees)	SME's (10–250 employees) ^a	Macro companies (more than 250 employees)
Environmental impact reduction	70%	63%	67%
Legislation adjustment	30%	55%	71%
Energy efficiency	60%	56%	56%
Cost reduction	65%	50%	32%
Marketing/Brand value	48%	40%	37%
Client demand/Fashionable	12%	19%	11%
To avoid economic sanctions	4%	3%	14%
To receive public benefits	7%	9%	7%

^a European Commission, 2005.

received, 410 were excluded due to incomplete surveys. The data from the excluded surveys was not eliminated and could be used in more specific studies in the future. Therefore, this study is based on 846 completed surveys, representing a valid response rate of 8.44%.

The standard profile of the system of study was analysed and matched up with the standard profile of the 8.44% of valid responses. Percentage coincidences were found in every variable. An analysis of Fig. 1 shows that respondents were predominantly male (66%), from 35 to 44 years old (39%), holding a managerial position (46%) from a SME company (37%) operating worldwide (31%) or in the Spanish economic market (30%). The main economic sectors of the system of study's companies are: Technology and Telecommunications (15%), Education and Training (13%), Consultancy and Engineering (12%), Public Government (10%), Communication and Marketing (8%) and Industry and Capital Goods (5%) and they are mostly from Catalonia (58%), Madrid (14%) and the Basque Country (6%).

Statistic analysis has focused on the first set of survey questions, which asked to macro, S&M and micro enterprises which the main drivers are to apply environmental criteria into their strategic plans. The statistic method applied has been Pearson Chi-square test (χ^2) and contingency tables analysis from software PASW Statistical 17. This procedure allowed to evaluate association and independence between two categorical variables (main drivers for applying environmental criteria in companies). Frequency in our case was the number of answers for each driver. Significant values inferior to $p < 0.05$ demonstrated that exists association between the studied variables. On the other hand values of significance higher than $p > 0.05$ demonstrate that variables are independent. In that case, it was interpreted as no exist any association between driving elements to integrate environmental criteria into the company and it's size. The analysis of adjusted residuals

(standardised) determined which driver in each type of company has more statistic weight. Adjusted residues values higher than +1.96 or lower than –1.96 demonstrated a high contribution to association between the drivers to integrate environmental criteria into the company and company size.

2.1.4. Limitations

Although some techniques were used to help neutralize response bias; a closed and anonymous survey was designed to be easy to fill in and questions and wording were kept simple with definitions provided. Characteristics from the system of study and the respondents were analysed. There were, however, several limitations to the survey. First, companies were not able to express their disinterest in answering the survey and simply return it. Furthermore, the survey is a self-assessment instrument, meaning the respondents answer based on their perceptions and represent their company, with no external audit of the validity or reliability of the answers.

3. Results and discussion

The results of the analysis are presented in three different blocks with regard to the main areas of the questionnaire: Perception, Reality and Future.

3.1. Perception: drivers, obstacles and environmental, eco-design and innovation attitudes. Driving elements for incorporating environmental criterion into strategic plans

As shown in Fig. 2 the first result of the analysis is that the innovator's perception of the main reasons for incorporating environmental criteria into strategic plans differs if they are referring specifically to the company they work for (internal vision) or to other companies (external vision). On the one hand, if innovators are referring to their own company the main drivers for integrating environmental criteria into strategic plans are environmental impact reduction (67%) and energy efficiency (57%). On the other hand, if innovators refer to companies in general, the perception is that companies integrate environmental criteria because of marketing and brand value (61%), and legislation adjustment (54%).

Table 1 shows that the size of the company influences its point of view. When innovators are asked to choose the three most important drivers among a list, environmental impact reduction is the most important for micro companies and SME's, while legislation adjustment is the preferred answer for macro companies.

Taking the results of Table 1, a statistical analysis of determinants for integrating environmental criteria into strategic plans of companies has been applied.

The obtained results demonstrate that exists a significant relationship ($\chi^2 = 119.52$, $p < 0.01$), with a low strength of association (Cramer's $V = 0.15$, $p < 0.01$), between the size of the company and the driving elements for incorporating environmental criteria into

Table 2

Statistical association between determinants for integrating environmental criteria into the strategic and company size.

			Driving elements									
			AES	CD/F	CR	EE	EIR	LA	MB	PB	DK/DA	Total
Company size	Micro	Answers count	10	29	157	145	169	73	116	17	3	719
		Adjusted residues	-2.1	-1.1	4.9	0.8	0.9	-6.4	2.1	-0.4	-1.3	-
	SME	Answers count	9	59	156	175	197	172	125	28	7	928
		Adjusted residues	-3.6	2.9	0.7	-0.4	-1.0	0.6	-0.4	1.1	-0.2	-
	Macro	Answers count	41	32	93	164	196	207	108	20	10	871
		Adjusted residues	5.6	-1.9	-5.4	-0.4	0.2	5.5	-1.5	-0.7	1.5	-

Driving elements: AES, Avoiding Economic Sanctions; CD/F, Client Demand and Being Fashionable; CR, Cost Reduction; EE, Energy Efficiency; EIR, Environmental Impact Reduction; LA, Legislation Adjustment; MB, Marketing and Brand value; PB, Public Benefits; DK/DA, Doesn't know, didn't answer. Proofs and symmetric measures: Pearson Chi-Square=119.52 ($p < 0.001$). Cramer's $V=0.15$ ($p < 0.001$).

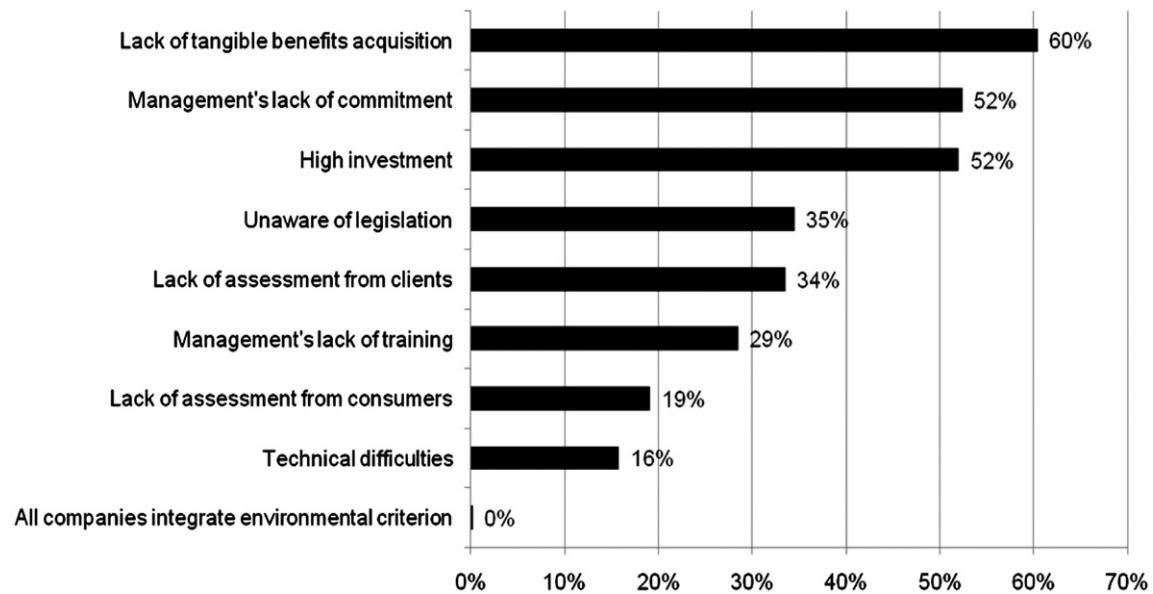


Fig. 3. Obstacles to the integration of environmental criteria into strategic plans.

strategic plans of companies. Furthermore the contingency table assessment allows to prioritize which driving elements are more relevant depending on the size of the company.

The obtained results show that for micro companies the driving element most considered is cost reduction, followed by marketing and brand value. On the other hand the driving elements less considered for micro companies are legislation adjustment and to avoid economic sanctions.

In the case of SMEs the main driver is the client demand and being fashionable and the least important is to avoid economic sanctions.

Finally for macro companies the most important drivers are to avoid economic sanctions and legislation adjustment. The least one is cost reduction.

Table 2 shows the answer counts and the adjusted residue values obtained from the contingency table analysis.

3.1.1. Obstacles to the incorporation of environmental criteria into strategic plans

The analysis of Fig. 3 refers to the obstacles that respondents believe that lead companies to avoid integrating environmental criteria into their strategic plans. Lack of acquisition of tangible benefits (60%) is the main motivation and refers to the absence of direct benefits in the short term, such as the growth of production

or sales, fiscal incentives or client satisfaction. Next is management's lack of commitment (52%) and the high investment (52%) that companies have to face when integrating environmental criteria.

Innovators do not see technical difficulties (16%) and lack of assessment from consumers (19%) as obstacles to the integration of environmental criteria into the strategic plans of companies. In any case respondents feel that all companies integrate environmental criteria (Fig. 3).

3.1.2. Environmental attitude

As shown in Table 3, there are a significant percentage of respondents that label their company as proactive (46%), meaning that sustainability is in the process of being integrated in the management of the company, through prevention techniques and management systems. Then, 8% of respondents label their company with an excellent attitude towards sustainability, meaning that the environmental criteria is a strategic factor in the organization.

There is trend among management staff (CEOs, Directors and Presidents) to label their company's attitude more positively than technical experts, government employees or university teachers (Table 4).

3.1.3. Knowledge

The percentage of respondents that know what the term eco-design means (57%), exceeds the percentage of respondents that do not know (35%) or those who gave no response (12%).

This result was checked in the questionnaire by making the respondents rank five possible eco-design definitions.

Table 3
Respondents' perception about their companies' attitude towards sustainability.

Label	Percentage	Description
Excellent	8%	Sustainability is a strategic factor in the company. The organization is creating economic, environmental and social value in the short and long term.
Proactive	46%	Sustainability is in the process of being integrated in the management of the organization through prevention techniques and management systems.
Reactive	22%	The organization strictly obeys environmental law.
Passive-indifferent	19%	Environmental issues do not affect corporate governance.
Negative	1%	Environmental issues pose a threat to the economic performance of the organization.
N/A	4%	

Table 4
Respondents' perception about their companies' attitude towards sustainability by position.

Label	CEO, Director, president	Technical expert	Government employees, university teachers
Excellent	11%	7%	1%
Proactive	48%	42%	44%
Reactive	22%	21%	28%
Passive-indifferent	17%	23%	22%
Negative	1%	2%	1%
No response	1%	5%	3%

Table 5
Specific eco-design strategies by cluster.

Main company cluster	Eco-design strategies	Percentage
Process	Efficient use of technology	59%
	Recycling	53%
	Waste minimization	51%
Product	Recyclable materials	51%
	Recycled materials	40%
	Low environmental impact materials	35%
Service	Selective waste collection	73%
	Double sided printing	53%
	E-mail billing and advertising	57%

3.2. Reality: specific eco-design strategies towards sustainability and their application in the supply chain

When answering about specific eco-design strategies, companies were clustered, with a simple question, into three categories: process, product or service innovation driven companies. Thus, respondents only answered about the strategies that were linked to one of these categories and if they had responded positively to a previous question about the introduction, or not, of environmental criteria into the design of their company products, processes or services.

Table 5 shows that process companies focus their eco-design strategies on the improvement of their activity in the factory subsystem (efficient use of technology, recycling and waste minimization), while product companies focus their eco-design strategies on the environmental improvement of materials (recyclable, recycled and low environmental impact materials) and less on strategies at other life cycle stages. Service companies focus their eco-design strategies on the minimization of resources and office automation recycling (selective waste collection, double sided printing and e-mail billing and advertising).

3.3. Future: predictions about eco-design in innovation frameworks

More than 90% of respondents believe that innovation could be a future catalyst for the integration of eco-design in companies.

According to Harvard Business Review (Nidumolu et al., 2009) smart companies now treat sustainability as the new frontier of innovation. Table 6 shows the specific eco-design strategies that respondents believe will lead to future innovations. Consolidated strategies such as using materials with a lower environmental impact (56%) or reducing the consumption of materials (54%) are maintained. New innovation strategies such as developing new concepts (60%) emerged. Less importance is given to optimizing the end of life (17%) or reducing the environmental impact at use stage (18%).

Table 6
Eco-design key strategies for future innovation within the companies.

Eco- design key strategy	Percentage
Developing new concepts	60%
Using materials with lower impact on the environment	56%
Reducing the consumption of materials	54%
Reducing use impact	18%
Optimize end of life	17%

Table 7

Future predictions on value chain activities regarding innovation and eco-design that could be hybridized.

Value chain activities	Percentage
Technology	62%
Operations	42%
Purchasing	32%
Services	31%
Distribution	27%
Logistics	23%
Management and administration	23%
Marketing and sales	22%
Customer service	15%
Human resources	10%

As shown in Table 7, the stages in the value chain where respondents found it easier to hybridize innovation and eco-design are technology (62%), operations (42%), purchasing (32%) and services (31%). Innovators do not find the hybridization of innovation and eco-design in customer service (15%) and human resources (10%) relevant.

4. Policy recommendations to foster eco-design in the Spanish context

According to the results presented in this paper and the background experience from the authors, the key policies to foster eco-design in the Spanish context are:

- a) Governmental support
 - Creation of an independent governmental body for the promotion of eco-design.
 - Implementation of economic support programs for companies.
 - Greening of public procurement.
 - Organization of competitions, awards and grants in recognition of leading eco-design projects.
- b) Tools and education
 - Creation of free eco-design tools (databases, software, calculation tools and other free information for companies).
 - Implement training on eco-design in university degrees and research centres.
 - Promotion of sustainable criteria among designers and foster their collaboration with businesses.
 - Development of a strong eco-labelling system.
 - Dissemination of eco-design to citizenship.

5. Conclusions

In this article, we have analysed how Spanish innovation driven companies are dealing with sustainability and eco-design issues. The crucial underlying argument exposed in this paper is that both concepts feed each other by generating a mindset that thrives in uncertain conditions.

First, the empirical study identified that there is a link between innovation performance and eco-design practices. Second, it demonstrates that respondents' perception, reality and vision of the future have specificities regarding company size, activity or the respondents' position. Thirdly, and to a broad extent, we have shown that even before the current economic recession, when companies had to look for new ways of coping with a period of uncertainty, Spanish innovators were already aware of new strategies for their products, processes and services and new ways of

delivering and capturing value to change the basis of competitiveness.

Implications for business strategy, public policy and future research can be drawn from these findings.

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Appendix. Summary of some of the main survey questions

1. Perception: causes, drivers, benefits and obstacles to sustainability, eco-design and innovation.

Why do you think that companies integrate environmental criteria into their strategic plans? (mark the 3 most important)

- ☐ Energy efficiency
- ☐ Cost reduction
- ☐ Environmental impact reduction
- ☐ Marketing/Brand value
- ☐ User demand/Fashionable
- ☐ Legislation adjustment
- ☐ To avoid economic sanctions
- ☐ To receive benefits
- ☐ Other reasons:
- ☐ There aren't any companies that integrate environmental criteria
- ☐ N/A

Why do you think that YOUR company integrates environmental criteria into its strategic plan? (mark the 3 most important)

- ☐ Energy efficiency
- ☐ Cost reduction
- ☐ Environmental impact reduction
- ☐ Marketing/Brand value
- ☐ User demand/Fashionable
- ☐ Legislation adjustment
- ☐ To avoid economic sanctions
- ☐ To receive public benefits
- ☐ Other reasons:
- ☐ There aren't any companies that integrate environmental criteria
- ☐ N/A

Why do you think that companies DO NOT integrate environmental criteria into their strategic plans? (mark the 3 most important)

- ☐ Unaware of legislation
- ☐ Involves a high level of investment
- ☐ Lack of acquisition of tangible benefits
- ☐ Lack of assessment from clients
- ☐ Lack of assessment from consumers
- ☐ Management's lack of commitment
- ☐ Management's lack of training
- ☐ Technical difficulties
- ☐ Other reasons
- ☐ All companies integrate environmental criteria
- ☐ N/A

1. Perception: causes, drivers, benefits and obstacles to sustainability, eco-design and innovation.

Could you label your company's environmental attitude?

- ☐ Excellent

Sustainability is a strategic factor in the company. The organization creates economic, environmental and social value in the short and long term.

- ☐ Proactive

Sustainability is starting to be integrated in the management of the organization through prevention techniques and management systems.

- ☐ Reactive

The organization strictly obeys environmental law.

- ☐ Passive-Indifferent

Environmental issues do not affect corporate governance.

- ☐ Negative

Environmental issues pose a threat to the economic performance of the organization.

- ☐ N/A

2. Reality: specific eco-design strategies towards sustainability and their application in the supply chain

Do the design of products, services and processes of your company integrate environmental criteria?

- ☐ Yes
- ☐ No
- ☐ N/A

Your company focuses on:

- ☐ Processes
- ☐ Products
- ☐ Services

3. Reality: specific eco-design strategies towards sustainability and their application in the supply chain

Specific eco-design strategies are as follows:
Processes

- ☐ Efficient technology use
- ☐ Renewable Energy
- ☐ Waste minimization
- ☐ Reuse of waste
- ☐ Recycling
- ☐ Returnable packaging
- ☐ Recycled packaging materials
- ☐ Distribution optimization
- ☐ Other strategies:

Products

- ☐ Recyclable materials
- ☐ Recycled materials

- ☐ Materials with a low impact on the environment
- ☐ Reduction of various materials
- ☐ Function integration in the same product
- ☐ Efficient collection system for product recollection
- ☐ Comprehensible instructions for product disposal
- ☐ Informative labelling on material components
- ☐ Minimization of transportation
- ☐ Optimization of product distribution
- ☐ Minimization of environmental impact in usage
- ☐ Minimization of waste in usage
- ☐ Design for longer useful life
- ☐ Other strategies:

Services

- ☐ Solar powered facilities
- ☐ Natural heating and lighting
- ☐ Energy saving light bulbs
- ☐ Special systems for reducing water consumption
- ☐ Energy saving appliances
- ☐ Eco-designed furniture (multifunctional, resistant, etc)
- ☐ Rewritable CDs
- ☐ Environmentally friendly cleaning products
- ☐ Multifunctional printers
- ☐ Use of recycled Ink toners and cartridges
- ☐ Selective waste collection
- ☐ Use of reusable cups for drinking water
- ☐ Double side printing
- ☐ Use of recycled paper or paper that is not bleached with chlorine
- ☐ Videoconferencing
- ☐ E-mail billing and advertising
- ☐ Environmental courses for employees
- ☐ Employee participation in office material purchasing
- ☐ Public transport promotion for employees and costumers
- ☐ Other strategies:

4. Future: envision of the eco-design in the innovation framework

Which strategies do you think that are going to lead to future innovations in your company?

- ☐ Developing new concepts
- ☐ Reducing the consumption of materials
- ☐ Using materials with less impact
- ☐ Minimization of environmental impact in production stage
- ☐ Optimization of distribution
- ☐ Reducing use impact
- ☐ Useful life increase
- ☐ Optimize the end of life
- ☐ N/A

Do you think that innovation will be a future catalyze for integration eco-design strategies into companies?

- ☐ Yes
- ☐ No
- ☐ N/A

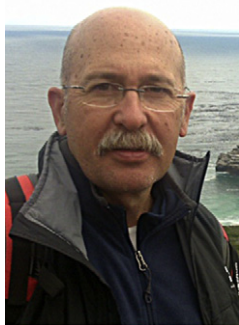
In which stages if the value chain is going to be easier to hybridize innovation and eco design

- ☐ Management and administration
- ☐ Human Resources

- ☐ Technology
- ☐ Purchasing
- ☐ Logistics
- ☐ Operations
- ☐ Distribution
- ☐ Marketing and sales
- ☐ Services
- ☐ Customer service
- ☐ N/A

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Joan Rieradevall Pons

Education: Ph. D., Science, Chemical Engineering, 1992 UAB, MBA, 1990 EADA, Department of Industry and Energy, and Department of Universities and Research, Degree in Environmental Engineering, 1981. **Current Position:** Researcher Institute of Environmental Science and Technology and Professor Department Chemical Engineering of Autonomous University of Barcelona. **Awards:** Premio 2007 Medio Ambiente Generalitat de Catalunya. Premio 2004 de proyectos sostenibles de la Ciudad de Barcelona (2004). Primer premio de Diseño para el Reciclaje 2000. Departamento de Medio Ambiente de Generalitat de Catalunya. (2001). Premio Ciudad de Barcelona, 1990 on environmental technology, in cooperation. Premio San Alberto Magno for Graduates, 1981, Chemical Associations. **Publications:** Over

140 articles in scientific and technical, 20 books and book chapters, abstracts in conventions, workshops on the Environment: LCA products, process and services, waste treatment, environmental planning and management, eco-design and energy recovery from biomass.



II. Maria Santolaria Barba

Education: Bachelors Degree in Environmental Science (2007, UAB); Master's Degree in Industrial Ecology (2008, UAB); Postgraduate diploma in Design and Innovation (2008, UPF-Elisava). **Current Position:** Innovation Consultant at Infonomia, a Spanish innovation services company that has a network of 25,000 eager professionals from all over the world. **Professional Experience:** In 2007 started to work as a Coolhunter at Infonomia and from 2008 she coordinates the annual event of the company, one of the most prestigious Innovation meetings in Spain, and co-organizes TEDxBarcelona, from the TED Brand.



Tito Morales Pinzón

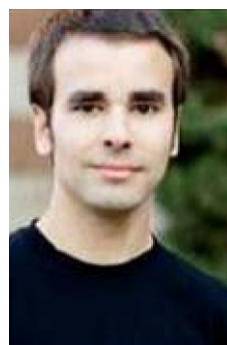
Education: Bachelor's Degree in Environmental Science (1998, U.T.P.-Colombia); Master's Degree in Operation Research and Statistic (2004, U.T.P.-Colombia). **Current Position:** Trainee Research Institute of Environmental Science and Technology of Autonomous University of Barcelona; member of the Research Group in Territorial Environmental Management (GAT) and Professor Environmental Science Faculty of Technological University of Pereira (Colombia).



CARLES MARTÍNEZ GASOL Environmental Sciences (PhD) Project manager carles@ineditnova.com Carles holds a PhD on Environmental Sciences (Autonomous University of Barcelona - UAB), where is an associate researcher In the research group on Sustainability and Environmental Prevention (SosteniPrA, www.sostenipra.cat). In the recent years Carles has been devoted to research on material, energy and economic balances of energy crops and on the application of biomass as fuel in industrial and urban systems.

In the teaching field is a teacher in the Master in Environmental Studies at UAB.

Carles is the Project manager of Inèdit, a company linked to the UAB Research Park, focused on providing applied research and innovative solutions in the field of sustainability to the urban environment, energy and agricultural products.



JORDI OLIVER I SOLÀ Environmental Sciences (PhD) Executive director jordi@ineditnova.com

Jordi holds a PhD on Environmental Sciences (Autonomous University of Barcelona - UAB), where is an associate researcher in the research group on Sustainability and Environmental Prevention (SosteniPrA, www.sostenipra.cat). In the recent years Jordi has been devoted to research on the environmental impacts of infrastructures in the public space in cities, and has authored several scientific articles on the subject.

In the teaching field is an associate professor at Elisava (UPF), where he teaches the subject of ecodesign. Additionally he participates in numerous postgraduate courses and masters.

Jordi is the Executive Director of Inedit, a company linked to the UAB Research Park, focused on providing applied research and innovative solutions

in the field of sustainability to the urban environment, energy and agricultural products.