What is Influencing the Sustainable Attitude of the Automobile Industry?

Angel Peiró-Signes, Ana Payá-Martínez, María-del-Val Segarra-Oña and María de-Miguel-Molina

Abstract The automotive industry is considered one of the most environmental aware manufacturing sectors. The aim of this study is to determine if there are any characteristics that differentiate automotive companies in environmental attitudes through the quantitative analysis of a sample of 224 companies belonging to the Spanish automobile industry. The chapter also provides an overview of the implications and constrains due to the integration of eco-design in a real company of the automotive sector giving a vision of the legislation applicable referred to eco-design, the adaptation of the constructor standards and some examples of general rules of the product and process design to satisfy these requirements, as well as the environmental policy that affects its decisions.

Keywords Automotive industry · Sustainability · Eco-design · Process and product design

A. Peiró-Signes (✉) · M. Segarra-Oña · M. de-Miguel-Molina
Universitat Politècnica de València, Valencia, Spain
e-mail: anpeisig@omp.upv.es

M. Segarra-Oña
e-mail: maseo@omp.upv.es

M. de-Miguel-Molina
e-mail: mademi@omp.upv.es

A. Payá-Martínez
Faurecia Certification and Systems, Valencia, Spain
e-mail: ana.paya@faurecia.com

P. Golinska (ed.), *Environmental Issues in Automotive Industry*,
EcoProduction, DOI: 10.1007/978-3-642-23837-6_3,

1 Introduction

The automotive industry is directing its efforts to incorporate the principle of the sustainable development, considering the service life of the product and involving the suppliers from first stage of design.

Suppliers play a vital role in the development and production of the vehicle; therefore they must be aligned with the customer environmental requirements and any applicable legislation. These requirements are provided by the customer at the beginning of the project and the requirements will be different depending on the commodity.

In order to be able to demonstrate the possibility of reaching the ratio of recycling and the absence of dangerous substances that allows the vehicle homologation, the vehicles constructors include in their requirements the report of all the materials and substances remaining on a vehicle at the sale point via the IMDS system (International Material Data System).

In the case of Ford Motor Company, for example, the certification according to ISO 14001 is an indispensable requirement to work as a supplier and the report in IMDS is a part of the Production Part Approval Process, which is the process for vehicle components' homologation. As an evidence of the initiative of the sector, it is possible to even emphasize that before the European Union adopted REACH (Registration, Evaluation, Authorization and Restriction of Chemical substances) regulation on chemical management or on end-of-life vehicles, companies like Ford Motor Company already had a material management system that allowed them to track all the substances and materials of the vehicle.

Another way to assure the fulfilment of the regulation is including this requirement as a part of the Manufacturing Site Assessment, that is, including this concept as a key element of the Q1, a set of quality and production disciplines and some indicators that Ford suppliers must follow to allow suppliers measurement of client expectations fulfilment.

Aligned with directive 200/53/EC, Ford Motor Company demands its suppliers that all the pieces must go labelled according to company standards, for later better recycling.

Suppliers must provide evidences of Design-for-Environment principles implementation (DfE), including Design-for-Disassembling (DfD) and Design-for-Recycling (DfR). One of the tools provided by the manufacturer of vehicles is the Design Verification Method to verify components recyclability by a recyclability evaluation.

The increase of recycled materials use is a requirement of the European directive and Ford Company requires suppliers to incorporate recycled materials in suitable components.

With the purpose of guaranteeing the requirement to provide the necessary information to the recycling companies so that end-of life vehicles are eliminated in a safe, economic and respectful way with the environment, several manufacturers of vehicles joined to create IDIS database (International Dismantling Information System), which compiles all this information.

During long time, the indicators considered as "classical" used by the companies in order to establish their targets have been dealing only with economic data, without considering social or environmental aspects.

To make sustainability a reality, the existing measuring tools need to determine where we are now and how far we need to go and whether humanity's demand remains within the interests of the globe's natural capital stocks (Wackernagel et al. 1999).

The ecological footprint indicator tries to fill in the gap. The ecological footprint is a measure of the load imposed by a given population on nature. It represents the land area necessary to sustain current level of resource consumption and waste discharge by that population (Wackernagel 2002).

By measuring the footprint of a population we can assess our pressure on the planet and will allow us to know how much nature we have, how much we use, and to track our progress toward the goal of a sustainable development (Munksgaard et al. 2005; Jorgenson and Burns 2007).

Today humanity uses the equivalent of 1.5 planets to provide the resources we use and absorb our waste. This means, it now takes the Earth 1 year and 6 months to regenerate what we use in a year.

In order to amend this situation it is important to establish sustainable development strategies. Implementing environmental strategies in the design phase will allow reducing the environmental impact of products during their service life and at their end of life (Wimmer et al. 2010) as in other leading industries (Criado 2007; Bohdanowicz 2005; Miret et al. 2011).

The consumer is increasingly becoming a citizen above all else, considering the ecological footprint of the products he or she buys, and the environmental impact of products. The question of use has become essential. When a choice is available, consumers are increasingly weighing their personal needs against their responsibility as citizens (Clark et al. 2009).

Some developed solutions to improve product design allowing its later recycling and reusability, although, at the moment, there are certain limitations in the technologies available in each country as many countries have still not invested in any specific treatment installation.

2 The Automotive Industry and the Environmental Awareness

As a result of these evolutions, the automobile status and role in daily life are changing. The automobile is becoming one choice among many in daily mobility, along with other means of individual transport (bicycles, scooters, rental cars) and collective transport (mass transit, carpooling, trains), although still indispensable in many areas around the world (Whitmarsha and Köhlerb 2010).

In this sense, the automotive industry, like other industries, must face the challenge to adapt product and process design to integrate environmental aspects (Schiavonne et al. 2008) as, every year, end-of life vehicles (ELVs) in the UE generate between eight and nine million tonnes of waste, which must be managed correctly (European Commission 2000). Volume of ELVs arising each year is increasing and it is expected to be 14 million tonnes by 2015 (Eurostat 2011). In this sense, Spain has to play a crucial role as five countries (Germany, UK, France, Spain and Italy) are responsible for approximately 75 % of EU 25 vehicle de-registrations (Eurostat 2011) and also holds an important part of Europe's automotive industry.

The present legislation tries to promote the use of recycled materials in the development of new vehicles and this is affecting the innovation processes of the companies, but is this compatible with customer specifications? How to use recycled materials in components that need to fulfil some certain mechanical or aesthetic characteristics? (Gerrard and Kandlikar 2007).

Environmental impact reduction and the consideration of the complete service life of the product must be objectives to deal with engineering specifications and to provide solutions with similar production costs as traditional development to date. Thus, design of vehicles for recycling and recovery, including their components and materials, as spare and replacement parts, might contribute to the protection, preservation and improvement of the environment quality and to energy conservation, although, waste generation must be avoided as much as possible (Santini et al. 2010; Ferrão and Amaral 2006).

Although, systems and facilities requirements for the collection, treatment and recovery of end-of life vehicles are important to ensure the attainment of the targets for reuse, recycling and recovery, producers meet all, or a significant part of the costs of all measures taken, and end-of life vehicle owner should deliver the vehicle into an authorized treatment facility without any cost. Then, design phase becomes crucial to ensure also companies profitability (Orsato and Wells 2007).

Preventive measures applied from the conception phase of the vehicle will improve the reduction and control of hazardous substances in vehicles, in order to prevent their release into the environment, and will facilitate recycling and avoid the disposal of hazardous waste.

Appropriate design will also help to ensure that certain materials and components do not become shredder residues, and are not incinerated or disposed of in landfills.

This will end integrating requirements for dismantling, reuse and recycling of end-of life vehicles and their components in the design and production of new vehicles.

The constant increase of the quantity for reuse, recycling and recovery must be a target in producers design phase as environmental policies pressures in that way and consumers are increasingly better informed and adjust their behaviour and attitudes towards environmental friendly products. Companies have been leading the efforts to incorporate the principles of designing for sustainability and the use of a lifecycle management approach (Segarra et al. 2011a).

Design for Environment principles into the product development process started in the early 1990s, however, they were initially focused on designing vehicles to facilitate end-of-life disassembly and recycling by taking into account the accessibility of parts to be disassembled, the type and number of different fasteners used and the marking of parts for easy identification.

Based on several studies, it became clear that focusing on a single lifecycle phase (e.g., end of life) leads to sub-optimizations and potentially increased impacts in other lifecycle phases.

Since then, companies have shifted their focus to include a more comprehensive lifecycle approach to improve the sustainability of vehicles, by incorporating the material and component production and the use phases, in addition to the end-of-life phase (Leduc et al. 2010).

Also, sustainability management tools have been applied in the new vehicles. These tools incorporate societal and economic aspects as well as environmental aspects into lifecycle analysis and design approach.

3 Regulation

The increase of the ecological awareness has been supported by the introduction of environmental regulation. The vehicles at the end of their life generate a great amount of residues that should have to be reused and recycled. The achievement of this activity is predefined especially due to the Directive 2000/53/EC, established by the European Parliament and the Council of End of Life Vehicles (ELV). The directive is been transferred to the different national laws and its main objective is the prevention of waste from vehicles and, in addition to this, the reuse, recycling and other forms of recovery of end-of-life vehicles and their components so as to reduce the disposal of waste. The Directive also aims to improve the environmental performance of all economic operators involved in the life-cycle of vehicles.

In order to be able to meet these objectives, the European Union has unfolded new requirements for vehicle manufacturers assuring the design of recyclable vehicles.

Priority must be given to the reuse and recovery (recycling, regeneration, etc.) of vehicle components aiming to increase its rate.

The reuse and recovery rate (in average weight per vehicle and year) should reach 85 % no later than January 1st 2006 and 95 % no later than January 1st 2015 (see Fig. 1).

The reuse and recycling rate (in average weight per vehicle per year) should reach 80 % no later than January 1st 2006 and 85 % no later than January 1st 2015 (see Fig. 1).

By the fulfilment of this directive it is expected to reduce the production of residues by limiting the use of hazardous substances in new vehicles, by designing

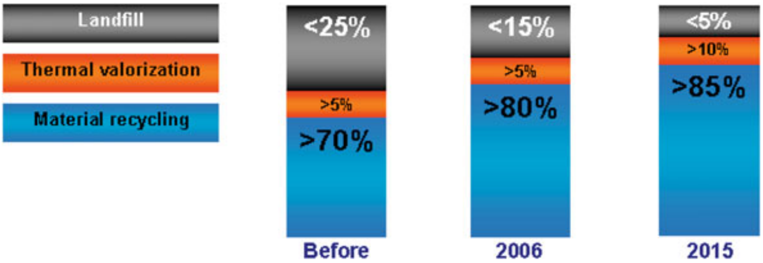

Fig. 1 Reuse and recycling rates

and producing vehicles which facilitate reuse and recycling and by developing the integration of recycled materials.

In order to make dismantling easier, manufacturers should meet codification standards for materials in their components to allow their identification, and should provide the necessary information to be able to realize the disassembling of the components (Fig. 2).

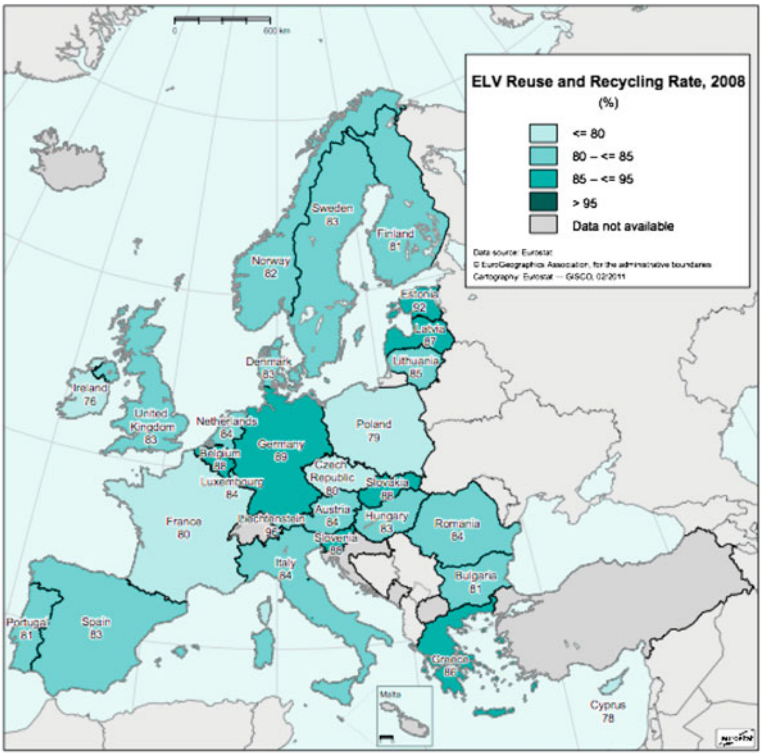

Fig. 2 ELV reuse and recycling rate in 2008 in EU, Source: Eurostat

Moreover, vehicles may be put on the market only if they meet the provisions of the EN ISO 22628:2002 (Road vehicles—Recyclability and recoverability—Calculation method).

As it is shown, government policies in developed countries have encouraged the development of markets for recycled materials, a certificate of destruction for the de-registration of end-of life vehicles, the growth of collection and treatment operators while recyclability and recoverability of vehicles have been promoted.

But, it is important to lay down requirements not only for storage and treatment operations but for vehicle and components manufacturing world round in order to avoid the emergence of distortions in trade and competition, especially with the developing countries.

4 Research Methodology

In this study, first, a collection and interpretation of data related to eco-design and sustainable development in the automotive sector has been made in order to characterize environmental orientation of the automotive industry companies while innovating.

Like most industries, the automotive industry is confronted with environmental issues namely: vehicle emissions, non-renewable material and energy consumption, generation of waste during production and at the end of life. There is an increasing stakeholders awareness, which finds its expression in new regulation and customer requirements (Manzini and Vezzoli 1998) Due to the wide range of environment impacts of the automotive industry different strategies have been launched to rectify this situation.

The study also tries to figure out if some of these qualitatively identified characteristics detected in leader companies of the automotive industry are followed by others and quantitative research will try to identify a model to differentiate environmental proactive companies from not proactive based on key indicators that have been identified in other studies (Segarra et al. 2011b).

To do so, a quantitative analysis has been performed. To establish environmental proactivity, four variables (used as dependent in each model) were taken into account:

- Importance of less materials per unit produced while innovating
- Importance of less energy consumption per unit produced while innovating
- Importance of less environmental impact while innovating
- Importance of environmental legislation requirements while innovating

It is important to identify the characteristics of the firms under study since these characteristics affect their environmental management practices.

This research analyzes a sample of 224 companies belonging to the Spanish automobile industry, some of them belonging to multinational companies. In line with Dubé and Pare (2003), well-known standardized statistical analysis methods, such as analysis of variance and regression analysis, have helped researchers confirm or reject hypotheses in quantitative research.

To reduce data variables a factorial analysis method was applied, allowing us to obtain homogeneous correlated variable groups. Furthermore, a logistic regression model, with the previous factor analysis results, was made to fit data.

The data was collected from PITEC database (Technological Innovation Panel), which consists of a statistical tool to monitor the technological innovation activities of Spanish companies. The database was built by the INE (Spanish National Statistics Institute) with the advice of academics and experts. A total of 255 variables were analyzed including a comprehensive list of Spanish companies which are characterized by the type of innovation (classified by the Oslo Manual, 2005) that they undertake, by industry (in line with the Spanish National Activities Classification, CNAE) or by geographical location. Data from 2009, the latest data available, was used for the analysis.

Variables included in this study were selected according to theoretical statements. Net sales (NS) represents the total sales income, size by number of employees (SZ) represents the number of full-time employees in the company, total goods investment (INVER) represents gross investment in tangible goods.

National market (MDONAC) indicates whether the companies operate on a national scale. E.U. market (MDOUE) indicates whether the companies operate on a European scale. Worldwide market (OTROPAIS) indicates whether the companies operate on a world wide scale rather than European Union. These are binary variables with 1 = Yes and 0 = No. The number of total patents (PATNUM), the number of European patents (PATEPO) and the number of national patents (PATOEPM) were measured respectively as the number of patent applications and the patents at the European and the Spanish levels.

Total investment in R&D activities (GTINN) represents the total expenditure in internal and external R&D activities and number of R&D employees (PIDCA) represents the number of full-time employees who work on R and D activities.

4.1 Qualitative Approach

4.1.1 Environmental Awareness at the Automobile Supplier Level: Faurecia's Case

Companies that work as vehicle manufacturers suppliers are a key element in a design that reduces the environmental impact of the automobile.

Faurecia is a specialist in the engineering and production of automotive components holds global leadership status in each of its core businesses: Automotive Seating, Emissions Control Technologies, Interior Systems and Automotive Exteriors. Its customer portfolio features practically every automaker around the world, including manufacturers in emerging economies, such as the Indian, Chinese and Korean markets.

With the aim of preparing good technical and economic practices, as well as fulfilling the effective legislation and the requirements of client, Faurecia has a set of specialists who form the eco-design department. This department is the one in charge of developing work standards that assure environmental aspects integration in the product and process design considering the complete service life of the product.

From the use of "green materials" to recycling, from the reduction of emissions to the reduction of weight, the concept of "clean car" is a complex subject with a broad scope.

Beginning with company's ethical code, Faurecia Group undertakes to implement actions aimed at respecting the environment and improving its protection.

In carrying out their daily activities, all Faurecia employees should be aware of their responsibilities towards protecting the environment, especially through the following commitments:

- Reduce waste and polluting products, conserve natural resources and recycle materials at each step in the manufacturing process;
- Actively pursue a development policy and implement technology capable of reducing polluting emissions.
- Constantly assess the impact of its products and the activity of its plants on the immediate environment and communities with a view to making constant improvements.

Different action lines like usage footprint reduction, with a strategy of innovation centred on light-weighting and emissions control technologies, and vehicle's ecological footprint reduction from production to end of life, through the use of more environmentally friendly materials and the implementation of cleaner production processes, show the commitment of the company with the environment.

To reduce economic dependence on petroleum materials as well as the environmental impact of their products, automotive manufacturers and suppliers are including more and more biomaterials (wood, hemps, linseed, wheat, beets, etc.) in their designs. Since the 1990s the Faurecia Group has been working on technologies combining polymers and natural fibbers for door panels. These natural fibbers can make up 50–90 % of a door panel. Also, polyolefins and fibers such as hemp and sisal are used for the creation of semi-structural parts, such as bumper supports, in place of glass fibers. The objective is to demonstrate the possible substitution of petroleum-based plastics by natural bio-based materials.

Additionally, production plants use environmental management tools to reduce the negative effects of industrial activity in the environment by the application of good practices in energy saving and waste generation, promoting recycling and reusing production processes that are more kind with environment conservation.

Certification of industrial sites (environmental management systems based on the ISO 14001 international standard) and training of employees to respect the environment have progressively been implemented, so 80 % of production sites were certified and more than 50 % of the people were trained by the end of 2009.

In 2008, all of the Group's facilities achieved a 3 % reduction in overall water consumption compared to 2007 and 46 % of the water consumed was recycled internally or disposed of naturally, with the rest directed to collective treatment facilities.

Similarly, energy consumption was reduced by 1 % between 2007 and 2008. This can be broken down into 34 % natural gas, 60 % electricity, and 4 % LPG (Liquid Petroleum Gas) fuels, and less than 2 % steam.

Logistic improvements, eco-friendly non-pollutant paints usage and other action have been manifested effective in reducing emissions.

At the same time, the updated Law on New Economic Regulation introduces mandatory HSE (health safety and environment) reporting for French corporations. Faurecia as French company listed on the French stock exchange is requested by the French law to report about the social and environmental impacts of its worldwide activities, such as energy consumption, atmospheric emissions, wastes, compliance with environmental regulation and legislation.

The NER is without a doubt one of the most important sustainability milestones in Europe or North America to date. For the first time on record, all listed corporations will have to publicly report on their triple bottom line -financial social and environmental- activities in both their annual and financial reports (2003, Eva Hoffmann. Environmental Reporting and Sustainability Reporting in Europe)

In the context, where some standards are getting more and more strict on emissions of CO_2 and antipollution, manufacturers and suppliers are increasing their efforts in the control and reduction of emissions to the atmosphere. For some years, the reduction of the weight has become an automotive industry priority.

Since Faurecia's products account for 15–20 % of a vehicle's weight, a responsibility and a commitment to lighten vehicles have been made to improve mileage and reduce pollution. Faurecia innovations will allow reducing the weight of their products by as much as 30 % by 2020.

Through light-weighting, new applications of natural materials and lowering emissions, Faurecia contributes to make the world less dependent on volatile oil supplies and helps promote a cleaner environment, as the reduction of the weight of the car in 10 kg is translated in a reduction of CO2 emissions of 1 gram by kilometre.

4.1.2 Design for Recycling (Environmental Orientation While Innovating)

Virtually all of the material in today's automobiles can technically be recycled. The challenge facing engineers is making this recycling process economical, especially for materials in such components as seats and instrument panels. Recycling these components requires different materials to be separated so that each can be recycled individually (Coulter et al. 1998).

Although the European Directive is very detailed concerning automotive materials and recycling recommendations it has no detailed instructions about how to do it at designing and production level. (De Medina 2006.

The goal of the Design-for-Recycling teams is to reduce the impact of substances originated materials of end of life vehicles and to promote later reusability.

Different measures have been developed to increase the potential recycling of the products, like the recycling production waste during the production process.

Design for recycling is oriented to facilitate the same in the materials and components of end of life vehicles, that's why the technologies of recycling available must be considered. The technologies available right now are: collection and de-pollution, dismantling and shredding.

For Faurecia there are three main options of recycling. According to these three options, general limitations of design and basic rules for the evaluation of recycling are considered from the design phase.

- Dismantling: in order to identify which pieces to disassemble with the correct labelling in visible zones, diminution of the number of materials, fixations that allow fast assembly and disassembling of components
- Post shredding floatation: The strategy of this process consists in recovering PP and PE with a density less than one, so that it floats. The objective is to take advantage of this technology to use PP and EP with a maximum of 10 % of mineral additives.
- Post shredding "Bulk recycling". It consists in classifying the residues in three categories: heavy, light and mineral.

The optimal design would happen by optimizing the product being recyclable in each of the three routes mentioned.

In the drawn map next, recycling technologies available in Europe are mapped (Fig. 3)

4.2 Quantitative Analysis

An exploratory factor analysis was performed on all independent variables, using Varimax method in an attempt to understand the factor structure and the corresponding measurement quality. The solution shows three factors which account for 78.96 % of the variance and significance 0.000, namely size, open market orientation, formal innovative activity (Table 1 shows the factor analysis results). All statistical analyses were carried out using SPSS for Windows, version 18.0.

Barlett's test of sphericity was calculated with the Kaiser–Meyer–Olkin statistic, to verify the suitability of the analysis. In line with Hair et al. (1998), it is usual to accept a solution explaining over 60 % of variance in social sciences. Factor estimates as well as the assessment of the overall fit were carried out using a principal component analysis, which was suitable to summarize the original information in factors for prospective purposes (Hair et al. 1998).

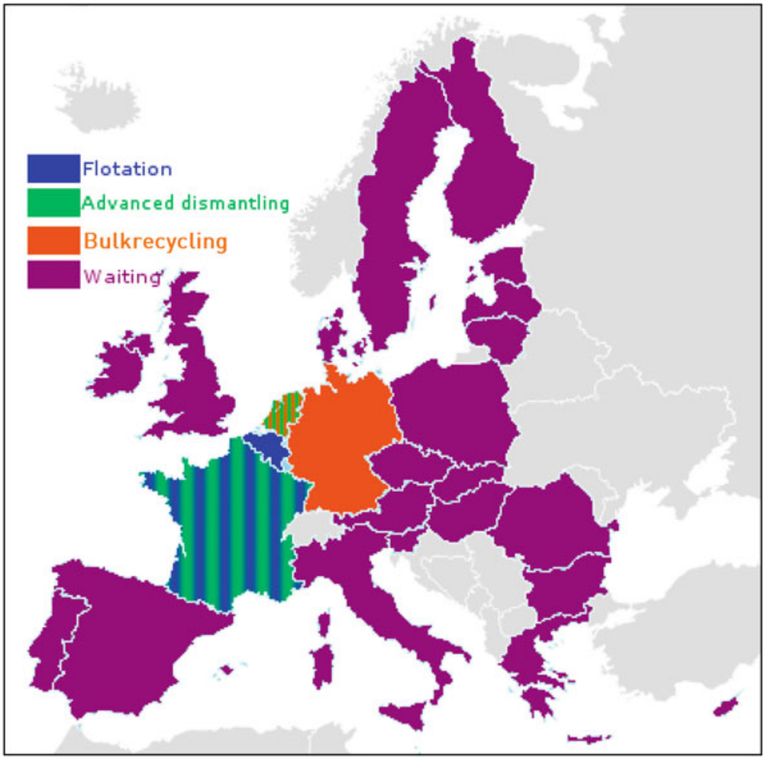

Fig. 3 Recycling technologies available in Europe per member

Table 1 Rotated component matrix

	Factor 1	Factor 2	Factor 3
NS	0.952		
INVER	0.887		
SZ	0.958		
MDONAC			0.672
MDOUE			0.821
OTROPAIS			0.773
GTINN	0.795		
PIDCA	0.817		
PATNUM		0.955	
PATOEPM		0.889	
PATEPO		0.915	

Rotation converged in four iterations. * Principal Component analysis. Varimax with Kaiser Normalization. 78.963 % variance explained -KMO, 756- Sig. 000

The factor loadings are the correlation coefficients between the variables and factors and the squared factor loading represents the percent of variance in that indicator variable explained by the factor.

High loadings have been considered to be six or higher (Hair et al. 1998) and are used to determine the cut-off.

Also scores were extracted to be used as variables in subsequent logistic regression.

The results of the Varimax rotation reinforced the expected pattern as Net sales, number of employees, total investment, total expenditure and employees in R&D activities refer to the size of the company. According to theory, larger structures involve more employees and higher sales. Moreover, the larger the company is, the greater the innovation investment (Churchill and Lewis 1987; Becker et al. 2005; Greiner 1997). All the variables which made up the first components were positively correlated and fitted the evolutionary theory of Nelson and Winter (2002).

National market (MDONAC), European Union market (MDOUE) and Worldwide market refers to market size, and thus market orientation becomes the second factor. According to theory (Salomon and Shaver Salomon 2005), innovation plays a crucial role in export behaviour and acts as a moderating factor in open market oriented firms.

Economic theory views patents as instruments aimed at fostering innovation and diffusion (Encaoua et al. 2006). The empirical evidence suggests that patents provide a fairly reliable measure of innovative activity (Acs et al. 2002) since innovation, growth and competitiveness are correlated (Crosby 2007). Thus, formal innovative activity is reflected as the third factor.

Factor scores from factor analysis were used as covariates in multinomial logistic regression. They have a mean of zero and a standard deviation of one.

The dependent variables of the models were modified from those called in PITEC database as OBJET9, OBJET10, OBJET11 and OBJET 13 which measure how essential it is for innovating firms to improve material consumption, energy consumption, the environmental impact or the environmental legislation accomplishment.

Dependent variables were recoded into binary dependent variable in order to differentiate High/medium oriented (value = 1) from Low/Not oriented firms (Value = 0) so they were designated with the suffix MOD.

Logistic regression can be used to predict a categorical dependent variable on the basis of continuous and/or categorical independents; to determine the effect size of the independent variables on the dependent; to rank the relative importance of independents; to assess interaction effects; and to understand the impact of covariate control variables. The impact of predictor variables is usually explained in terms of odds ratios.

Note that logistic regression calculates changes in the log odds of the dependent, not changes in the dependent itself.

Binary logistic regression predicts the “one” value of the dependent, using the “zero” level as the reference value.

Table 2 Odds ratio for b coefficients in the model and Wald statistic significance value

	OBJET9MOD	OBJET10MOD	OBJET11MOD	OBJET13MOD
SIZE	1.662 (0.054)	1.5 (0.068)	8.551 (0.027*)	1.244 (0.183)
F. R&D	1.629 (0.208)	0.976 (0.873)	2.919 (0.043*)	1.239 (0.41)
EXPORT	1.13 (0.43)	1.201 (0.245)	1.407 (0.038*)	1.505 (0.014*)
Intercept	1.273 (0.095)	1.041 (0.775)	1.634 (0.036*)	1.136 (0.364)

* Significant if $p < 0.05$

Intercepts are the log odds of the dependent when predictors are at their average values.

Wald statistic significance and the odds ratio are shown in Table 2. Odds ratios are effect size measures. The odds ratio is the natural log base, e, to the exponent of the parameter estimate, b, and, for continuous variables, the odds ratio represents the factor by which the odds (event) change for a one-unit change in the variable.

Results show that independent variables are significant only the model found for OBJET11MOD in determining whether a company is high or medium oriented toward environmental impact while innovating or rather have low or not orientation.

From the model we can found that SIZE has the greater impact in changing the odds of being high/medium oriented rather than low/not oriented. We may say that when the independent variable increases one unit, that is the company has a value in the variable SIZE obtained one standard deviation higher than the mean value for the sample, the odds that the dependent is equal to 1, increase by a factor of 8,55, when other variables are controlled.

Then we can conclude that, size, formal R&D Activities and Export orientation influence with different impact on the environmental orientation of the firms in the automobile industry while innovating.

Variables studied show that are not able to discriminate between companies in the automobile industry that set the reduction of materials and energy per unit as an objective of high/medium importance or low/not importance while innovating. Neither for the objective of accomplishing environmental legislation requirements.

5 Conclusions

In this study have been emphasized a wide range of actions that a leader automotive company like Faurecia, has been taken over the past few years. This chapter reflects the information collected after the interview with eco-design experts from Faurecia Group to detect environmental objectives followed while the innovating process is taking place, mainly in the design phase.

Observed results are reinforced by the empirical results that show that environmental orientation is influenced by the company's characteristics.

For the Spanish automotive firms, the study has detected that environmental proactivity while innovating is determined mainly by the size of the firms, measured by the total income, total investment, size R&D investment and R&D employees, and also, but less, by the formal R&D activity (number of patents) and export orientation.

Accordingly with the results, bigger companies with higher number of patents and with a wider international presence are more likely to be environmentally oriented when they are innovating. As automotive firm's innovations are focused and take part mainly on the design phase of products, we can conclude that eco-design is more likely to take part in big companies with high external and innovation orientation and that these companies are eco-innovation drivers throughout the automotive industry.

The study also has found no significant differences on companies' characteristics attending the importance of other aspects like energy and material reduction or environmental legislation accomplishment while innovating. Although, energy and material reduction might be related to environmental innovation, they are also highly influenced by operational facts, so company orientation might be affected by other variables like economic performance, costs structure or its financial situation.

Further research will continue to explore the specific characteristics of the automotive industry when facing eco design and other related environmental issues.

Acknowledgments The authors would like to thank the Universitat Politècnica de València for supporting the UPV-PAID 2011-1879_ First Projects Funding and the sabbatical research of M. Segarra. Also the Spanish Economy and Competitiveness Ministry for its financial support through the research project (EC02011-27369), and Faurecia for providing helpful information.

References

Acs ZJ, Anselin L, Varga A (2002) Patents and innovation counts as measures of regional production of new knowledge. Res Policy 31(7):1069–1085

Bohdanowicz P (2005) European hoteliers' environmental attitudes: greening the business. Cornell Hospitality Quart 46(2):188–204

Becker MC, Lazaric N, Nelson RR, Winter SG (2005) Applying organizational routines in understanding organizational change. Ind and Corp Change 14(5):775–791

Churchill NC, Lewis VL (1987) The five stages of small firm growth. Long Range Plan 20(3):45–52

Clark G, Kosoris J, Hong LN, Crul M (2009) Design for sustainability: current trends in sustainable product design and development. Sustainability 1(3):409–424

Coulter S, Bras B, Winslow G, Yester S (1998) Designing for material separation: lessons from automotive recycling. Trans Am Soc Mech Eng J Mech Des 120:501–509

Criado E (2007) Reflexiones sobre el futuro de la Industria Europea de la Cerámica. Boletín de la Sociedad Española de Cerámica y Vidrio 46(1):39–44

Crosby M (2007) Patents, innovation and growth. Econ Rec 76(234):255–262

De Medina HV (2006) Eco-design for materials selection in automobile industry, In: Proceeding of the comunicação técnica elaborada para o 13th CIRP internacional conference on life cycle engineering, LCE 2006—towards a closed loop economy, Leuven, pp 299–304

Dubé L, Paré G (2003) Rigor in information systems positivist case research: current practices, trends, and recommendations. Mis Quart 27(4):597–636

Encaoua D, Guellec D, Martínez C (2006) Patent systems for encouraging innovation: lessons from economic analysis. Res Policy 35(9):1423–1440

European Commission (2000) Environmental data centre on Waste_Data Directive 2000/53/EC, epp.eurostat.ec.europa.eu› European Commission

Eurostat (2011) End-of-life vehicles: Detailed data, http://appsso.eurostat.ec.europa.eu/nui/show.do

Ferrao P, Amaral J (2006) Assessing the economics of auto recycling activities in relation to European union directive on end of life vehicles. Technol Forecast Soc Change 73(3):277–289

Gerrard J, Kandlikar M (2007) Is European end-of-life vehicle legislation living up to expectations? Assessing the impact of the ELV Directive on "green" innovation and vehicle recovery. J Clean Prod 15(1):17–27

Greiner LE (1997) Evolution and revolution as organizations grow: a company's past has clues for management that are critical to future success. Family Bus Rev 10(4):397–409

Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL (1998) Multivariate data analysis. Prentice Hall, New Jersey

Jorgenson AK, Burns TJ (2007) The political-economic causes of change in the ecological footprints of nations, 1991–2001: a quantitative investigation. Soc Sci Res 36(2):834–853

Leduc G, Mongelli I, Uihlein A, Nemry F (2010) How can our cars become less polluting? An assessment of the environmental improvement potential of cars. Transp Policy 17(6):409–419

Manzini E, Vezzoli C (1998) Agenzia nazionale per la protezione dell'ambiente. Lo sviluppo di prodotti sostenibili: i requisiti ambientali dei prodotti industriali. Maggioli, Italy

Miret Pastor L, Segarra Oña M, Peiró Signes A (2011) Cómo medimos la ecoinnovación?: análisis de indicadores en el sector turístico (how to rate ecoinnovation?: A tourism sector indicator's analysis), Tec Empresarial 5(2):15–25

Munksgaard J, Wier M, Lenzen M, Dey C (2005) Using input_output analysis to measure the environmental pressure of consumption at different spatial levels. J Ind Ecol 9(1–2):169–185

Nelson RR, Winter SG (2002) Evolutionary theorizing in economics. J Econ Persp 16:23–46

Orsato R, Wells P (2007) The automobile industry and sustainability. J Cleaner Prod 15(11–12):989–993

Salomon R (2005) Learning from exporting: new insights, new perspectives. Edward Elgar Publishing, Cheltenham

Santini A, Morselli L, Passarini F, Vassura I, Di Carlo S, Bonino F (2010) End-of-life vehicles management: Italian material and energy recovery efficiency. Waste Manage (Oxford) 31(3):489–494

Schiavone F, Pierini M, Eckert V (2008) Strategy-based approach to eco-design: application to an automotive component. Int J Veh Des 46(2):156–171

Segarra-Oña MV, De-Miguel-Molina M, Payá-Martínez A (2011a) A review of the literature on eco-design in manufacturing industry: Are the institutions focusing on the key aspects? Rev Bus Inform Syst 15(5):61–67

Segarra-Oña M, Peiró-Signes A, Albors-Garrigós J, Miret-Pastor P (2011b) Impact of innovative practices in environmentally focused firms: moderating factors. Inter J Environ Res 5(2):425–434

Wackernagel M, Onisto L, Bello P, Callejas Linares A, López Falfán I, Méndez García J, Suárez Guerrero A, Suárez Guerrero G (1999) National natural capital accounting with the ecological footprint concept. Ecol Econ 29:375–390

Wackernagel M (2002) T Tracking the ecological overshoot of the human economy. Proc Natl Acad Sci USA 99(14):9266–9271

Whitmarsh L, Köhler J (2010) Climate change and cars in the EU: the roles of auto firms, consumers, and policy in responding to global environmental change. Cambridge J Reg Econ Soc 3(3):427

Wimmer W, Lee KM, Quella F, Polak J (2010) Outlook: sustainability–what does the future hold? ECODESIGN–Compet Adv 18:191–194