UNIVERSIDAD POLITÉCNICA DE VALENCIA

Estudio de la interrelación entre el eco-diseño y la eco-innovación e identificación de aspectos clave en la innovación sostenible en un sector industrial: aplicación al sector del automóvil.

TESIS DOCTORAL

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Resumen

El respeto al medioambiente está calando en la sociedad moderna a todos los niveles. Los ciudadanos, las instituciones públicas y también las empresas son conscientes del papel que desempeñan en la protección del entorno. Este trabajo busca profundizar en los conceptos relacionados con el medioambiente que afectan a las decisiones que las empresas toman en el día a día. Por la relación de la autora con el sector del automóvil, en el que he desarrollado mi actividad profesional desde el año 1999, la aplicación empírica se ha realizado en esta industria con el objetivo principal de identificar los aspectos sobre los que se debe incidir para potenciar las actuaciones mediomentalmente proactivas.

Como actividades clave para el sector se ha analizado en profundidad el diseño y la innovación que, al incluir el enfoque sostenible, se estudian en la tesis como eco-diseño y eco-innovación.

Así, en primer lugar se realiza una revisión bibliográfica sobre el eco-diseño, los beneficios que se derivan para las empresas al considerar la mejora medioambiental a través del mismo así como los que se derivan de la actitud proactiva y de su implementación, como por ejemplo la mejora de la posición competitiva, la reducción de costes, la mejora de la imagen de la empresa o el desarrollo de nuevos productos.

En esta primera parte se identifica también el principal obstáculo que las empresas encuentran, que se resume en la falta de incentivos y de apoyo para que las empresas puedan potenciar e implementar las actuaciones de eco-diseño.

En el segundo estudio, se analizaron las acciones concretas que una empresa automotriz líder como Faurecia ha desarrollado en los últimos años. A través del estudio de este caso de manera profunda, se presenta la información recogida mediante entrevistas con expertos en eco-diseño del grupo Faurecia. Los resultados observados a nivel particular en Faurecia se refuerzan por los resultados empíricos obtenidos sobre empresas pertenecientes al sector que muestran que la orientación ambiental está influenciada, principalmente, por las características de la empresa. Para las empresas de automoción españolas, el estudio detectó que la proactividad ambiental al innovar viene determinada, principalmente, por el tamaño de las empresas medido por las variables: ingreso total, inversión total, cantidad de inversión en I+D y el número de empleados en

I+D y también, aunque menos, por la actividad formal en I+D (número de patentes) y la orientación exportadora de la empresa. Así, las grandes empresas con mayor número de patentes y con presencia internacional son más propensas a ser medioambientalmente activas en actividades de eco-diseño y eco-innovación y que son este tipo de empresas las que lideran la actividad y la orientación medioambiental en el sector del automóvil español.

Por otra parte, aunque la reducción en el uso de la energía y de material también se han relacionado con la eco-innovación, están muy influenciados por otras variables como el rendimiento económico, la estructura de costes o su situación financiera, por lo que no se pudo concluir nada al respecto.

La investigación prosiguió explorando las características específicas de la industria automotriz frente al eco-diseño y otras cuestiones ambientales relacionadas. Así, el siguiente artículo que conforma esta tesis doctoral, se planteó con el propósito de identificar los impulsores de la orientación ambiental de las empresas del sector del automóvil. En concreto, se analizó la importancia de la tipología de las fuentes de información procedentes del entorno (denominadas "de mercado"; proveedores, clientes, competidores y consultores externos) para orientar eficazmente mejoras de productos y procesos como factores claves para determinar la orientación ambiental de las empresas del sector. Utilizando el paquete de software SmartPLS 2.0, el modelo de medición fue confirmado con suficiente fiabilidad y validez para todas las hipótesis.

Además, el modelo estructural demostró que todos los coeficientes de la ruta fueron estadísticamente significativos. Los resultados de nuestro estudio, consistentes con trabajos previos, destacan cómo las actividades de eco-innovación están positivamente relacionadas con la innovación. Las empresas que se centran en productos y procesos cuando innovan son más eco-innovadoras que el resto.

La consistencia de los resultados sugiere que las compañías que buscan, por una parte, una mayor flexibilidad operativa, aumentar la capacidad de producción, reducir los costes laborales unitarios o reducir el consumo energético por unidad cuando están buscando innovaciones, están también más dispuestas a adoptar una orientación ambiental y, por otra, las empresas que se centran en el desarrollo de nuevos productos, en aumentar o sustituir la gama de productos, en aumentar la calidad del producto o en alcanzar una mayor cuota de mercado o nuevos mercados, son también más propensas a ser medioambientalmente más proactivas.

Este enfoque aclara los aspectos más importantes a tener en cuenta en relación a la orientación ambiental de las empresas del sector del automóvil. Se deduce de los resultados que la promoción de la innovación definitivamente llevará a promover la orientación ambiental.

Por último, nos planteamos identificar grupos de empresas, dentro del sector, con similares comportamientos con respecto al medioambiente y con diferentes mecanismos de potenciación de su actividad eco-innovadora con el objetivo de clarificar el tipo de actuaciones que desarrollan cada uno de ellos.

Se identifican tres grupos de empresas claramente diferenciados. El principal grupo de empresas dentro del sector, los "eco-balanced", se orientan hacia el medio ambiente equilibrando la orientación interna para mejorar procesos y reducir el impacto ambiental y el coste. Buscan nuevos productos de mercado y nichos relacionados con la demanda "verde".

En otro grupo de empresas, los "eco-marketers", la orientación hacia el mercado es más fuerte que la orientación hacia los procesos. Este grupo está también altamente influenciado por las fuentes de información de mercado, es decir, proveedores, competidores y clientes.

Finalmente, el último grupo se opone a la tendencia general, la actividad innovadora del grupo hacia el mercado actúa negativamente en la orientación ambiental de las empresas cuando innovan. Parece que este grupo no es capaz o no quiere ver la oportunidad que los aspectos ambientales les ofrecen, son los que hemos llamado "eco-blinds".

Los resultados de esta investigación permiten clasificar a las empresas del sector del automóvil en cuanto a su respuesta y su comportamiento hacia el medioambiente. También permite identificar los aspectos que influyen en esta clasificación, lo que facilita la toma de decisiones y la identificación de los aspectos a mejorar.

La combinación de técnicas de tipo cualitativo y cuantitativo ha permitido entender el proceso y realizar los análisis para obtener conclusiones que benefician directamente al entramado empresarial nacional y más concretamente a las empresas del sector del automóvil que pueden ver potenciado su nivel competitivo si aprovechan las oportunidades que la sostenibilidad y el respeto hacia el medio ambiente les brindan.

Resum

El respecte al medi ambient està calant en la societat moderna a tots els nivells. Els ciutadans, les institucions públiques i també les empreses són conscients del paper que exerceixen en la protecció de l'entorn. Aquest treball busca aprofundir en els conceptes relacionats amb el medi ambient que afecten les decisions que les empreses prenen en el dia a dia. Per la relació de l'autora amb el sector de l'automòbil, en el qual he desenvolupat la meva activitat professional des de l'any 1999, l'aplicació empírica s'ha realitzat en aquesta indústria, amb l'objectiu principal d'identificar els aspectes sobre els quals s'ha de indicir per potenciar les actuacions mediomentalmente proactives.

Com a activitats clau per al sector s'ha analitzat en profunditat el disseny i la innovació que, en incloure l'enfocament sostenible, s'estudien en la tesi com ecodisseny i ecoinnovació.

Així, en primer lloc es realitza una revisió bibliogràfica sobre l'ecodisseny, els beneficis que es deriven per a les empreses en considerar la millora mediambiental a través del mateix, així com els que es deriven de l'actitud proactiva i de la seva implementació com per exemple, la millora de la posició competitiva, la reducció de costos, la millora de la imatge de l'empresa o el desenvolupament de nous productes.

En aquesta primera part s'identifica també el principal obstacle que les empreses troben, que es resumeix en la manca d'incentius i de suport perquè les empreses puguin potenciar e implementar les actuacions d'ecodisseny.

En el segon estudi, es van analitzar les accions concretes que una empresa automotriu líder com Faurecia ha desenvolupat en els últims anys. A través de l'estudi d'aquest cas de manera profunda, es presenta l’informació recollida mitjançant entrevistes amb experts en ecodisseny del grup Faurecia. Els resultats observats a nivell particular en Faurecia es reforcen pels resultats empírics realitzats sobre empreses pertanyents al sector que mostren que l'orientació ambiental està influenciada, principalment, per les característiques de l'empresa. Per a les empreses d'automoció espanyoles, l'estudi va detectar que la proactivitat ambiental al innovar ve determinada, principalment, per la grandària de les empreses mesurat per les variables: ingrés total, inversió total, quantitat d'inversió en R + D i el nombre deempleados en R + D i també, encara que menys, per l'activitat formal en R + D (nombre de patents) i per l'orientació

de exportadora de l'empresa. Així, les grans empreses amb major nombre de patents i amb presència internacional són més propenses a ser mediambientalment actives en activitats d'ecodisseny i ecoinnovació i que són aquest tipus d'empreses les que lideren l'activitat i l'orientació mediambiental en el sector de l'automòbil espanyol.

D'altra banda, tot i que la reducció en l'ús de l'energia i de material també s'han relacionat amb l’ecoinnovació ambiental, estan molt influenciats per altres variables com el rendiment econòmic, l'estructura de costos o la seva situació financera, de manera que no es va poder concloure res sobre això.

L’investigació va prosseguir explorant les característiques específiques de l´indústria automotriu davant del ecodisseny i altres qüestions ambientals relacionades. Així, el següent article que conforma aquesta tesi doctoral, es va plantejar amb el propòsit d'identificar els impulsors de l'orientació ambiental de les empreses del sector de l'automòbil. En concret, es va analitzar la importància de la tipologia de les fonts d'informació procedents de l'entorn (denominades "de mercat", proveïdors, clients, competidors i consultors externs) per orientar eficaçment millores de productes i processos com factors claus per determinar l'orientació ambiental de les empreses del sector. Utilitzant el paquet de programari SmartPLS 2.0, el model de mesura va ser confirmat amb suficient fiabilitat i validesa per a totes les hipòtesis. A més, el model estructural demostrà que tots els coeficients de la ruta van ser estadísticament significatius. Els resultats del nostre estudi, consistents amb treballs previs, destaquen com les activitats d'eco-innovació estan positivament relacionades amb la innovació. Les empreses que se centren en productes i processos quan innoven són més eco-innovadores que la resta.

La consistència dels resultats suggereix que les companyies que busquen, d'una banda, una major flexibilitat operativa, augmentar la capacitat de producció, reduir els costos laborals unitaris o reduir el consum energètic per unitat quan estan buscant innovacions estan también.más disposades a adoptar una orientació ambiental i, per altra, les empreses que se centren en el desenvolupament de nous productes, en augmentar o substituir la gamma de productes, a augmentar la qualitat del producte o en assolir una major quota de mercat o nous mercats, són també més propenses a ser mediambientalment més proactives.

Aquest enfocament aclareix els aspectes més importants a tenir en compte en relació a l'orientació ambiental de les empreses del sector de l'automòbil. Es dedueix dels resultats que la promoció de la innovació definitivament portarà a promoure l'orientació ambiental.

Finalment, ens plantegem identificar grups d'empreses, dins del sector, amb comportaments respecte al medi ambient i amb diferents mecanismes de potenciació de la seva activitat eco-innovadora amb l'objectiu d'aclarir el tipus d'actuacions que desenvolupen cadascun d'ells.

S'identifiquen tres grups d'empreses clarament diferenciats. El principal grup d'empreses dins del sector, els "eco-balanced", s'orienten cap al medi ambient equilibrant l'orientació interna per millorar processos i reduir l'impacte ambiental i el cost. Busquen nous productes de mercat i nínxols relacionats amb la demanda "verda".

En un altre grup d'empreses, els "eco-marketers", l'orientació cap al mercat és més fort que l'orientació cap als processos. Aquest grup està també altament influenciat per les fonts d'informació de mercat, és a dir, proveïdors, competidors i clients.

Finalment, l'últim grup s'oposa a la tendència general, l'activitat innovadora del grup cap al mercat actua negativament en l'orientació ambiental de les empreses quan innoven. Sembla que aquest grup no és capaç o no vol veure l'oportunitat que els aspectes ambientals els ofereixen, són els que hem anomenat "eco-blinds".

Els resultats d'aquesta investigació permeten classificar les empreses del sector de l'automòbil quant a la seva resposta i el seu comportament cap al medi ambient. També permet identificar els aspectes que influeixen en aquesta classificació, la qual cosa facilita la presa de decisions i la identificació dels aspectes a millorar.

La combinació de tècniques de tipus qualitatiu i quantitatiu ha permès entendre el procés i realitzar les anàlisis per obtenir conclusions que beneficien directament a l'entramat empresarial nacional i més concretament a les empreses del sector de l'automòbil que poden veure potenciat el seu nivell competitiu si aprofiten les oportunitats que la sostenibilitat i el respecte pel medi ambienbte els brinden.

Abstract

Respect for the environment is permeating the modern society at all levels. Citizens, public institutions and companies are aware of their role in the protection of the environment. This work seeks to deepen in the concepts related to the environment that affect the decisions that firms take in they day to day. Due to the relationship of the thesis author with the automotive industry, in which I have developed my professional activity since 1999, the empirical application has been done in this industry, with the main aim of identifying the aspects on which reshape is due to promote proactive environmental actions.

As industry´s key activities design and innovation were analysed in depth, and as the sustainable approach is included, eco-design and eco-innovation are the topics centering the research. So, first a literature review on eco-design is done, benefits from the eco design attitude and implementation have been clearly identify in the literature review, as competitiveness improvements, cost reduction, better company image or new product development, but what several researchers have pointed out is that industry need supporting tools for achieving eco design goals.

In the second paper, a wide range of actions that a leader automotive company like Faurecia has been taken over the past few years have been emphasized. 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.

In the third part, the purpose was to identify some of the driving forces behind the environmental orientation of the automotive companies. Specifically, this research proposed the importance of the market information sourcess (coming from suppliers, clients, competitors and external consultants) to effectively orientate product and process improvements as the key factors in determining the environmental orientation of the automotive industry firms. Using SmartPLS 2.0 software package, the measurement model was confirmed with sufficient reliability and validity for all of the constructs in the research model. Further, the structural model demonstrated that all of the path coefficients were statistically significant.

The consistency in findings would suggest that companies that look for more operational flexibility, to increase production capacity, to reduce labor costs per unit or to reduce energy consumption per unit when they are looking for new innovations are more willing to adopt an environmental orientation too.

On the other hand, firms focused on new products, on increasing or substituting product range, on increasing product quality or on reaching greater market share or new markets, are also more likely to be environmentally orientated.

Finally, we aim to identify groups of companies within the industry, with different behaviour towards the environment and different mechanisms of enhancement of eco-innovative activity with the objective of clarifying the types of activity carried out by each of them.

We found 3 groups of companies which environmental orientation while innovation is driven differently. The biggest group of companies orientate towards environment balancing the internal orientation to improve processes and reduce environmental and cost impact and searching for new market products and niches to tap on the new green demand, eco-balanced.

In another group of companies, market orientation is pushing harder than processes to orientate companies' environmental innovation activity. This group is also highly influenced in the innovation process by the market information sources, namely, suppliers, competitors and clients. We called them eco-marketers.

Finally, the last group is opposing the general tendency in those relations, so this group innovative activity towards the market is acting negatively in the environmental orientation of the firms when innovating. It seem, that this group is not able or don't want to see the general path to approach environmental aspects in the innovation process. We called them eco-blind.

Results of this research allow us to classify the automobile sector companies regarding their reactions and their behaviour towards the environment. It also allows us to identify the aspects that influence this classification, which facilitates the decision-making process and the identification of ways to improve their Environmental orientation. The combination of qualitative and quantitative analysis´ techniques has allowed us to deeply understand the process and to obtain conclusions that benefit directly the national business structure and, more specifically, the automobile industry´s companies who can see their competitive level empowered if they take advantadge of the opportunities that the sustainability and that respect for the environment offer them.

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Índice:

CAPÍTULO 1

INTRODUCCIÓN

1. Introducción.

Hasta el momento, los indicadores utilizados por las compañías para fijar sus objetivos se han basado, principalmente, en datos económicos, sin considerar aspectos medioambientales o sociales (Ramos y Caeiro, 2010). Para hacer realidad la sostenibilidad medioambiental, la interacción entre los principios económicos y el desarrollo tecnológico necesita ser observado cuidadosamente al diseñar la responsabilidad extendida del productor (EPR), e incentivada desde un punto de vista económico (Wiesmeth y Häckl, 2011). Este enfoque de progreso sostenible, económico y social se denomina "Triple Bottom Line" en la literatura académica (Sullivan, 2002; Bonilla et al., 2010).

Aceptando su responsabilidad social y medioambiental, la industria del automóvil debe afrontar el desafío de adaptar el diseño de producto y del proceso integrando aspectos medioambientales (Schiavone et al., 2008) mientras se enfrenta a los aspectos medioambientales relacionados con las emisiones del vehículo, el material no renovable y el consumo de energía y la generación de residuos durante la producción (Nunes y Bennett, 2010; Deif, 2011). Por otra parte, hay una creciente concienciación de los distintos grupos sociales de interés, que encuentra su expresión en nuevos requisitos de la legislación y de los clientes (Manzini y Vezzoli, 1998). Debido a la amplia gama de impactos medioambientales de la industria del automóvil, una amplia diversidad de estrategias sostenibles se han puesto en marcha para afrontar esta situación (González et al., 2008), siguiendo los estamentos básicos definidos por el "diseño según los principios del medioambiente" (Suh, 1990) y el "acercamiento del diseño verde" (Zuburtikudis, 2001). Este concepto, el "green design", definido como las opciones disponibles para alinear inversiones ambientales y sociales con la estrategia genérica de la compañía (Orsato, 2009), ha supuesto el punto de partida en la industria de fabricación para acercarse al desarrollo sostenible, siendo un aspecto diferenciador clave en su posicionamiento competitivo (Pigosso et al., 2010; Schiavone et al., 2008).

La aplicación directa de esos preceptos en la industria del automóvil, se interpreta, de manera simplificada, como que la generación de residuos debe evitarse tanto como sea posible (Santini et al., 2010; Ferrão y Amaral, 2006), siendo un aspecto fundamental que el diseño de los vehículos facilite el desmontaje y reciclado al final de la vida útil teniendo en cuenta la accesibilidad de las piezas a desmontar, el tipo y el número de diversas sujeciones usadas y el marcado de las piezas para su fácil identificación (Morrison, 2000; Gerrard y Kandlikar, 2007; Subramoniam et al., 2009; Santini et al., 2010).

Pronto se puso de manifiesto la necesidad de dirigir esfuerzos a incorporar el principio de desarrollo sostenible a lo largo de la vida de servicio del producto y de implicar a los proveedores desde la primera fase de diseño (Guide y Van Wassenhove, 2001; MacLean y Lave, 2003). Así, las compañías se han centrado en incluir un acercamiento más completo del ciclo de vida para mejorar la sostenibilidad de los vehículos incorporando la fase de producción del material y de los componentes y la fase de uso, además de la fase de fin-de-vida (Smith y Crotty, 2008; Leduc et al., 2010).

El aumento de la concienciación ecológica se ha visto también ayudada por la introducción de legislación medioambiental (Ferrão y Amaral, 2006), especialmente debido a la directiva 2000/53/EC , establecida por el Parlamento Europeo y el Consejo de Vehículos al Final de su vida útil (ELV). Su objetivo es mejorar el funcionamiento medioambiental de todos los operadores económicos implicados en el ciclo de vida de los vehículos reduciendo la producción del residuo, limitando el uso de sustancias peligrosas en nuevos vehículos, diseñando y produciendo los vehículos que faciliten la reutilización y el reciclado, y desarrollando la integración de materiales reciclados (Gross, 2008).

Por este motivo, el eco-diseño se considera un campo emergente, tanto para la investigación como para su aplicación práctica, que puede ayudar a las organizaciones a mejorar su funcionamiento medioambiental (Bhamra, 2004), y se considera una eco-innovación (Manual de Oslo, 2005). Son muchos los autores que consideran que resulta crucial para asegurar, por un lado, la rentabilidad de las empresas (Porter y Van der Linde, 1995; Pujari, 2006; Orsato y Wells, 2007; Ambec y Lanoie, 2008) y, por otra parte, la correcta orientación de la estrategia de las empresas (Segarra et al., 2011a)

Hasta la fecha, algunos autores han centrado su investigación en temas medioambientales y en su aplicación en la industria del automóvil (Keoleian, 1993, 1997; Geffen y Rothenberg, 2000), aunque aún es escasa la investigación que se ha llevado a cabo sobre la conexión entre la eco-innovación y el eco-diseño y su impacto en la industria del automóvil.

Esta tesis ayuda a llenar este vacío estudiando qué aspectos relacionados directamente con el eco-diseño están siendo considerados por las compañías al innovar en la industria del automóvil. Identifica aquellos aspectos fundamentales a la hora de determinar la orientación medioambiental de las empresas cuando innovan, proponiendo y validando un modelo de las relaciones entre los mismos. Por último, identifica 3 segmentos de empresas dentro del sector desvelando la importancia relativa y la naturaleza de las relaciones anteriormente identificadas.

2. Objetivos de la investigación.

Moviéndose hacia una economía y una sociedad sostenibles, la eco-innovación desempeña un papel fundamental puesto que permite aumentar el valor para los productores y los consumidores mientras que reduce las consecuencias para el medio ambiente (Van Berkel, 2007). El campo de la eco-innovación incluye la modificación de modelos de producción y consumo pero también el desarrollo de tecnologías, de productos y de servicios para reducir nuestro impacto en el ambiente (Comisión Europea, 2009).

En esta línea, hay varios estudios que se centran en la industria del automóvil. Aragón-Correa et al. (2008) estudiaron el sector de los recambios del coche, concluyendo que las compañías con las prácticas más proactivas tenían mejores resultados económicos. Simpson et al. (2007) estudiaron la cadena de suministro del automóvil en Australia reforzando la importancia de inversiones en activos específicos en la relación entre los requisitos de un funcionamiento medioambiental de los clientes y el potencial de mejorar las responsabilidades medioambientales de los proveedores. Zhu et al. (2007) fueron pioneros al analizar los programas piloto internos y externos idóneos para implementar los sistemas de gestión de la cadena de suministro sostenible entre las compañías chinas del automóvil, y son varios los autores que han seguido esta línea de trabajo en los últimos años (Simpson et al., 2007; Walker et al., 2008). González-Torre et al. (2009) estudiaron la industria del automóvil española desde el análisis de la logística inversa, remarcando la importancia de las barreras externas e internas para implementarla.

Más específicamente, Carrillo-Hermosilla et al. (2010) concluyeron que hay varios aspectos que influyen en el desarrollo de las eco-innovaciones, como el diseño, la tipología de los usuarios, el uso final del producto y los aspectos reguladores.

El diseño se considera el aspecto clave que influye en el resto de las dimensiones identificadas. De lo anteriormente expuesto, se deduce que hay actualmente una necesidad de analizar la inclusión real del eco-diseño en la industria de fabricación del automóvil y de las necesidades que las compañías tienen para mejorar su posicionamiento medioambiental a través del eco-diseño. Las ventajas de la aplicación del eco-diseño se han identificado en la revisión de la literatura como mejoras de la competitividad, reducción de costes, una mejor imagen de empresa o el desarrollo de nuevos productos. Lo que varios investigadores han señalado es que la industria necesita instrumentos de apoyo para alcanzar los objetivos del eco-diseño; métodos y herramientas más simples y fáciles de utilizar para los diseñadores, tales como eco-indicadores, para ser utilizados durante fases tempranas de diseño en el desarrollo del concepto del producto (Persson, 2001) y una necesidad cada vez mayor de herramientas para verificar la conformidad de un producto con normas y estándares (Houe y Grabot, 2007).

Y, aunque estemos de acuerdo en que el eco-diseño es una parte crucial en la industria del automóvil, la pregunta que se plantea es si el eco-diseño debe ser considerado como una parte diferente de las actividades medioambientales de las compañías de fabricación o si podemos analizarlo como parte de la actividad eco-innovadora para mejorar el direccionamiento de políticas públicas. En esta línea de estudio, planteamos como primera pregunta de investigación si *las empresas del sector del automóvil consideran de manera distinta las actuaciones de diseño sostenible y las actividades de eco-innovación.*

Y, de manera más específica, pensamos que, aunque entre sus objetivos se encuentra el de diseñar su producto de manera sostenible, los objetivos buscados son parciales y, por tanto, pretendemos valorar si *las compañías del automóvil, al innovar, consideran esencial la reducción de materiales, la importancia de la reducción del* *consumo de energía por unidad producida, la reducción del impacto ambiental o la importancia de los requisitos de la legislación ambiental entre otros*, lo que constituirá nuestra segunda pregunta de investigación.

Por tanto, esta tesis tiene como objetivo general contribuir al conocimiento del eco-diseño y de la eco-innovación. Se ha definido el problema a tratar como **“Estudio de la interrelación entre el eco-diseño y la eco-innovación e identificación de aspectos clave en la innovación sostenible en un sector industrial: aplicación al sector del automóvil.”.**

Esta tesis se estructura como un compendio de artículos de forma que la estructura de los capítulos que incluyen los artículos se corresponde con el formato exigido por las revistas para su revisión y posterior publicación (resumen, introducción, marco teórico, objetivos, resultados y conclusiones y bibliografía).

En el Capítulo 1 se realiza la introducción de la tesis y la presentación de los objetivos del estudio. Posteriormente se justifica la utilización de los datos escogidos para la tesis y las metodologías utilizadas.

En el Capítulo 2 se incluye el artículo: **“A review of the literature on eco-design in manufacturing industry: Are the institutions focusing on the key aspects?”** Este artículo ha sido publicado en Volumen 15 Número 5 de la revista *Review of Business Information Systems* – Special Edition 2011. La citada revista está indexada en: ABI Inform, Australian Research Council (ARC), Cabell’s Directory (Accounting, Management, & Computer Science and Business Information Systems Directories), EBSCO Discovery, EBSCO’s Education Research Complete, Google Scholar, J-Gate, ProQuest, Ulrich’s Periodicals, Copernicus Journal Master List (índice de impacto 2011: 4.44).

En el Capítulo 3 se presenta el trabajo: **“What is influencing the sustainable attitude of the automobile industry?”**, aceptado para su publicación como capítulo de libro en *Environmental Issues in Automotive Industry*, editado por la prestigiosa editorial Springer- Verlag (2014).

El Capítulo 4 está constituido por el artículo: **“Factors influencing eco-innovation orientation of the automobile firms”.** Este capítulo ha sido aceptado para su publicación en la revista *Engineering Management Journal* que gestiona la American Society for Engineering Management. Esta revista está indexada en la base de datos Journal Citation Report con factor de impacto 0,365. Su publicación está prevista en marzo 2014.

En el Capítulo 5 lo conforma el artículo **"Grouping firms attending to their environmental orientation: an empirical study of the Spanish automotive industry".** Este artículo se encuentra en proceso de revisión en la revista *Proceedings Of The Institution Of Mechanical Engineers, Part D: Journal Of Automobile Engineering* indexada en el JCR Science Edition con un factor de impacto de 0,583.

Finalmente, en el Capítulo 6 se presentan las conclusiones de la tesis doctoral, las limitaciones del estudio realizado y se definen las futuras líneas de investigación.

3. Datos del estudio y sus características

En el primer trabajo se aborda la situación actual del eco-diseño, las definiciones académicas y las principales variables que afectan a su implantación en la industria.

A continuación se realiza un doble análisis; por una parte un estudio de un caso y, por otra, el análisis empírico de la situación del sector del automóvil a nivel nacional.

La empresa analizada es Faurecia, multinacional francesa con sede en Valencia. Se estudian las actuaciones que la empresa desarrolla en cuanto a eco-diseño y comportamiento ecoinnovador.

Para desarrollar el estudio cuantitativo, se analizaron 224 empresas pertenecientes a la industria del automóvil española (empresas ubicadas en España). Teniendo en cuenta que sólo cinco países (Alemania, Reino Unido, Francia, España e Italia) son responsables de aproximadamente el 75% de las bajas de vehículos de EU (Eurostat, 2011), podemos considerar que la muestra de estas empresas españolas es suficientemente relevante para determinar la orientación medioambiental de la industria del automóvil.

Los datos utilizados en este estudio provienen del panel de innovación tecnológica (PITEC). PITEC es un instrumento estadístico diseñado con el objeto de seguir las actividades de innovación tecnológica de empresas españolas. Esta base de datos se inició en 2004 por el INE con la colaboración de investigadores de la universidad y con el patrocinio de FECYT y Cotec al objeto de mejorar la información sobre las actividades tecnológicas de las empresas. Este instrumento permite, por tanto, la realización de investigaciones científicas sobre dichas actividades.

Aunque la base de datos está formada por observaciones repetidas a lo largo de los años de las distintas variables que la componen, en este estudio se ha utilizado una vision estática de los mismos. En consecuencia los valores utilizados para realizar los diferentes análisis estadísticos se basan en el conjunto de datos seleccionados para un periodo concreto, típicamente, el último periodo disponible en el momento de la realización del análisis.

En este estudio se accedió a la base de datos que se encuentra a disposición de cualquier investigador en el portal de la FECYT.

Los ficheros utilizados han sufrido un proceso de “anonimización” de una serie de variables para evitar que las empresas encuestadas puedan ser identificadas. El proceso de anonimización que realiza el INE introduce modificaciones que afecta principalmente a las variables cualitativas. Por otra parte, reemplaza las actividades CNAE originales por una agrupación en 44 actividades de forma que estos grupos recogen en ciertos casos varios códigos CNAE.

El proceso de anonimización no afecta al propósito de la investigación, ya que uno de los grupos establecidos (código CNAE-2009: 29) coincide específicamente con la población objetivo del estudio de esta tesis doctoral (ver Tabla 1), “vehículos de motor”.

Tabla 1. Tabla códigos ACTIN de la base de datos PITEC.

Código (ACTIN)	Rama de actividad	CNAE-2009
0000	AGRICULTURA, GANADERÍA, SILVICULTURA Y PESCA	01, 02, 03
0001	INDUSTRIAS EXTRACTIVAS	05, 06, 07, 08, 09
0002	INDUSTRIAS DEL PETRÓLEO	19
0003	ALIMENTACIÓN, BEBIDAS Y TABACO	10, 11, 12
0004	TEXTIL	13
0005	CONFECCIÓN	14
0006	CUERO Y CALZADO	15
0007	MADERA Y CORCHO	16
0008	CARTÓN Y PAPEL	17
0009	ARTES GRÁFICAS Y REPRODUCCIÓN	18
0010	QUÍMICA	20
0011	FARMACIA	21
0012	CAUCHO Y PLÁSTICOS	22
0013	PRODUCTOS MINERALES NO METÁLICOS DIVERSOS	23
0014	METALURGIA	24
0015	MANUFACTURAS METÁLICAS	25
0016	PRODUCTOS INFORMÁTICOS, ELECTRÓNICOS Y ÓPTICOS	26
0017	MATERIAL Y EQUIPO ELÉCTRICO	27
0018	OTRA MAQUINARIA Y EQUIPO	28
0019	VEHÍCULOS DE MOTOR	29
0020	CONSTRUCCIÓN NAVAL	301
0021	CONSTRUCCIÓN AERONÁUTICA Y ESPACIAL	303
0022	OTRO EQUIPO DE TRANSPORTE	30 (exc. 301, 303)
0023	MUEBLES	31
0024	OTRAS ACTIVIDADES DE FABRICACIÓN	32
0025	REPARACIÓN E INSTALACIÓN DE MAQUINARIA Y EQUIPO	33
0026	ENERGÍA Y AGUA	35, 36
0027	SANEAMIENTO, GESTIÓN DE RESIDUOS Y DESCONTAMINACIÓN	37, 38, 39
0028	CONSTRUCCIÓN	41, 42, 43
0029	COMERCIO	45, 46, 47
0030	TRANSPORTES Y ALMACENAMIENTO	49, 50, 51, 52, 53
0031	HOSTELERÍA	55, 56
0032	TELECOMUNICACIONES	61
0033	PROGRAMACIÓN, CONSULTORÍA Y OTRAS ACTIVIDADES INFORM	62
0034	OTROS SERVICIOS DE INFORMACIÓN Y COMUNICACIONES	58, 59, 60, 63
0035	ACTIVIDADES FINANCIERAS Y DE SEGUROS	64, 65, 66
0036	ACTIVIDADES INMOBILIARIAS	68
0037	SERVICIOS DE I+D	72
0038	OTRAS ACTIVIDADES	69, 70, 71, 73, 74, 75
0039	ACTIVIDADES ADMINISTRATIVAS Y SERVICIOS AUXILIARES	77, 78, 79, 80, 81, 82
0040	EDUCACIÓN	85 (exc. 854)
0041	ACTIVIDADES SANITARIAS Y DE SERVICIOS SOCIALES	86, 87, 88
0042	ACTIVIDADES ARTÍSTICAS, RECREATIVAS Y DE ENTRETENIMIEN	90, 91, 92, 93
0043	OTROS SERVICIOS	95, 96

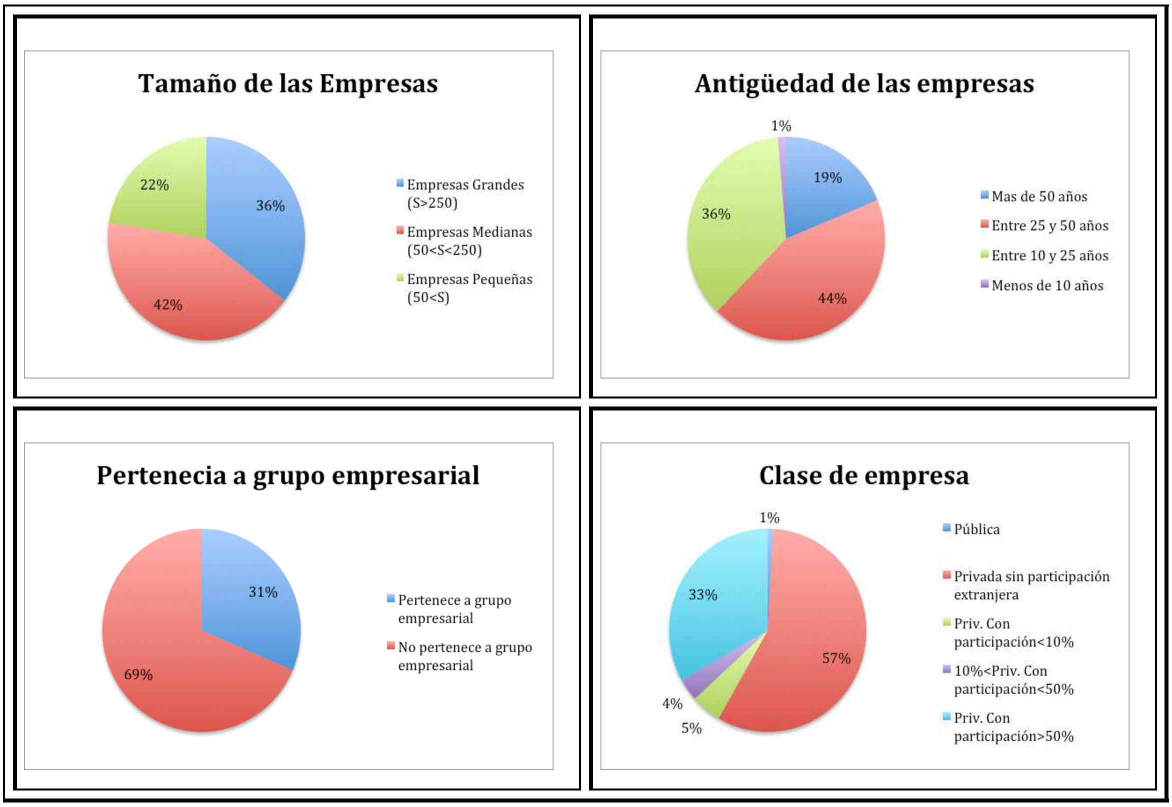
Fuente: Diseño Registro PITEC (2012)

Mediante el estudio previo del diseño de la base de datos y de sus variables, se determinó el conjunto de variables de interés para realizar cada uno de los estudios de que consta esta Tesis Doctoral. Se descargó el fichero correspondiente de forma que en columnas se recogió número total de variables incluidas en PITEC y en filas los valores de dichas variables para cada una de las empresas presentes en la base de datos.

Posteriormente se filtraron los datos por código CNAE, utilizando la variable ACTIN, conforme a lo indicado anteriormente para obtener datos de la industria del automóvil.

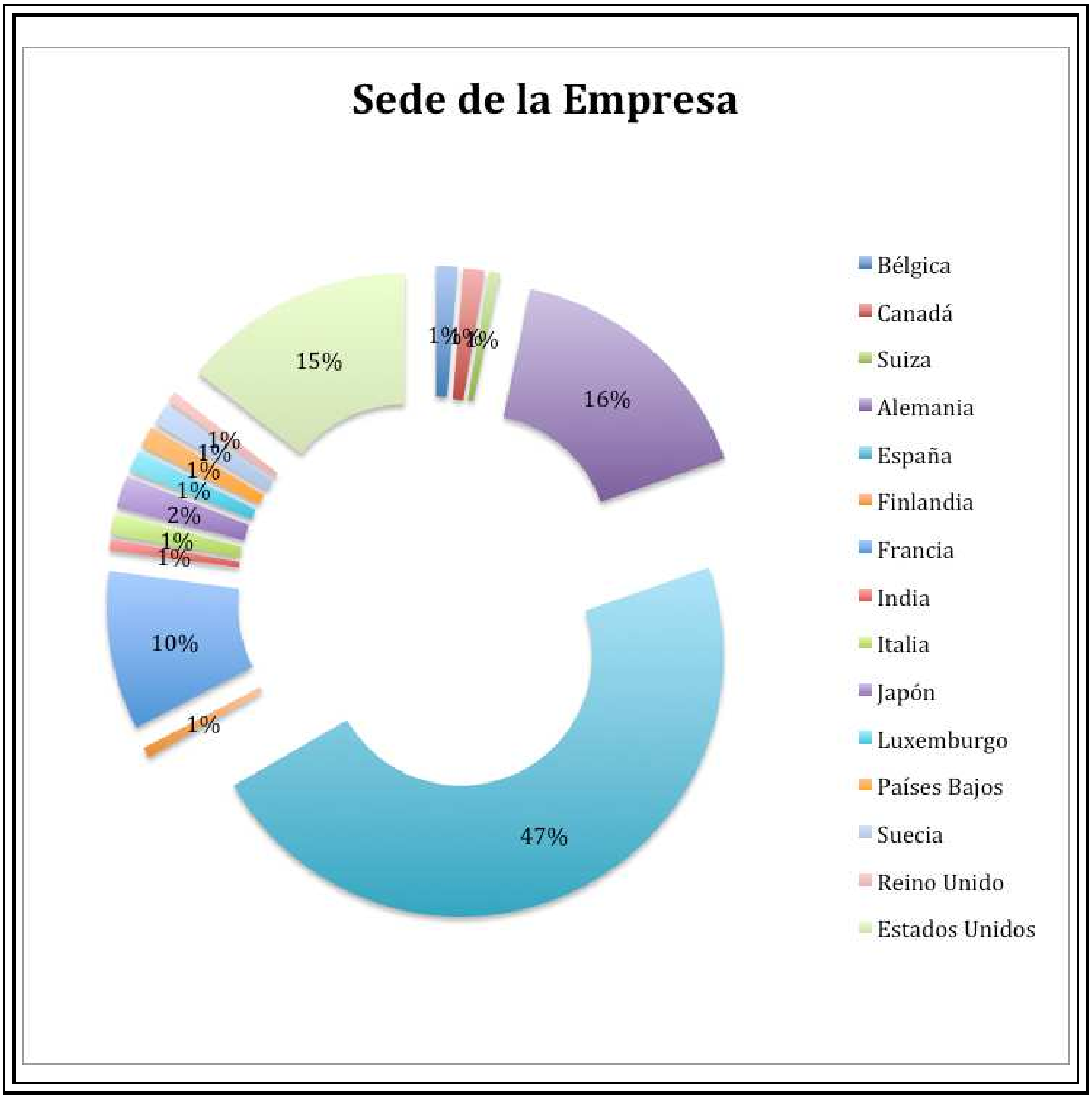
La muestra de 224 empresas está formada por un 36% de empresas grandes (más de 250 trabajadores), un 42 % de empresas medianas (entre 50 y 250 trabajadores) y un 22% de empresas pequeñas (menos de 50 trabajadores). Estas empresas en su gran mayoría, 44%, tienen una antigüedad de entre 25 y 50 años. El 36% de las empresas tiene entre 10 y 15 años, mientras el 19% supera los 50 años. Sólo un 1% de la muestra tiene una antigüedad inferior a 10 años.

Figura 1. Características de la muestra



Fuente: Elaboración propia a partir de datos de PITEC (2010)

Figura 2. Países de localización de la sede de las empresas de la muestra.



Fuente: Elaboración propia a partir de datos de PITEC (2010)

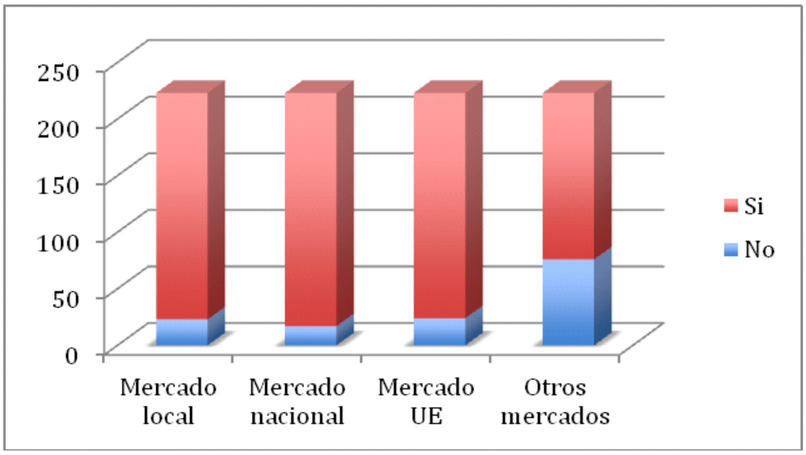
En lo que se refiere a la clase de empresa, aproximadamente un tercio pertenece a un grupo empresarial. El 57% de las empresas de la muestra son de capital privado sin participación extranjera y un tercio del total son privadas con al menos el 50% de capital extranjero. Como se puede esperar sólo un pequeño porcentaje, un 1%, tiene carácter público.

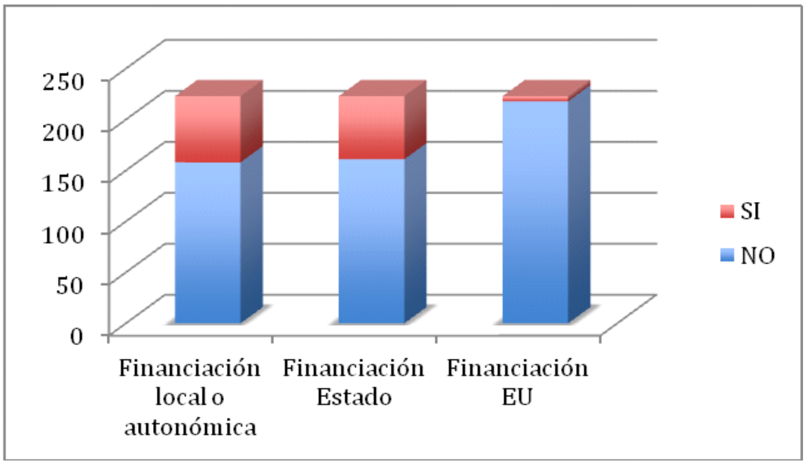
La distribución de la sede de cada una de las empresas por países nos indica, como era de esperar, que la mayoría de las empresas que no tienen su sede en España, se encuentran afincadas en países europeos donde la industria automovilística tiene una importancia relativamente alta (Alemania y Francia).

En cuanto a la orientación exportadora de las empresas de la muestra, podemos decir que la mayoría de las empresas tienen como mercado objetivo el mercado de la Unión Europea, mientras que algo más de un tercio comercializa sus productos en países extracomunitarios.

En cuanto a la financiación, aproximadamente un cuarto de las empresas reciben financiación local, autonómica o estatal, mientra que sólo un pequeño grupo de empresas recibe financiación europea.

Figura 3. Orientación exterior y financiación pública de las empresas de la muestra.





Fuente: elaboración propia a partir de datos de PITEC (2010)

En consecuencia, tenemos a nuestra disposición una muestra bastante heterogénea en tamaños, edad, país de origen y composición de accionariado.

La configuración de la información presente en PITEC se demostró adecuada para su tratamiento estadístico mediante los paquetes informáticos utilizados en cada uno de los artículos que componen esta tesis. En consecuencia, no fue necesario ningún tratamiento de los datos previo al análisis estadístico de los mismos.

4. Metodología.

El formato seguido en la elaboración de esta tesis consiste en el compendio de tres artículos publicados en revistas académicas internacionales que han aplicado evaluación externa anónima. Cada uno de ellos aborda las diferentes fases en las que se ha dividido este estudio, y su conjunto explica el contenido de esta tesis.

La metodología utilizada en los artículos se ajusta a los propósitos de cada uno de los estudios realizados y se expone brevemente a continuación.

4.1. Revisión bibliográfica

Una revisión bibliográfica es una recopilación sistemática de la información publicada relacionada con el tema de la investigación. La búsqueda bibliográfica es un proceso complejo y fundamental dentro de proceso de investigación. Las preguntas de investigación que nos planteamos inicialmente nos llevarán a referencias a los artículos relacionados con el objeto del estudio. Asimismo, éstos nos conducen a más referencias de interés que enriquecen nuestra investigación. El objetivo de esta técnica dentro de una tesis doctoral es proporcionar un marco de las investigaciones realizadas hasta el momento en el tema de estudio para poder identificar vacíos de investigación que permitan generar un proyecto de investigación que enriquezca el conocimiento existente y represente una aportación relevante a dicho conocimiento.

4.2. Estudio de casos

El estudio de casos es un instrumento o forma de investigación cualitativa, que implica el examen intensivo y profundo de un mismo objeto de estudio mediante un proceso de indagación sistemática. Se caracteriza por el examen detallado y comprensivo del caso objeto de interés.

El estudio de casos es una metodología de investigación importante en el ámbito de la administración de empresas. Aunque sus conclusiones no son generalizables estadísticamente, ofrece importantes resultados e información que, en muchas ocasiones, no puede ser encontrada por medio de los métodos cuantitativos y que es muy valiosa para la toma de decisiones en las empresas.

Por tanto, podemos encontrar nuevas evidencias o situaciones de un fenómeno o encontrar el porqué de los resultados de un estudio cuantitativo.

4.3. Análisis factorial

El análisis factorial se utiliza para descubrir la estructura latente (dimensiones) de un conjunto de variables. Reduce el espacio de atributos a partir de un mayor número de variables a un número menor de factores. El análisis factorial se puede utilizar entre otros para los siguientes fines:

- Para reducir un gran número de variables a un número menor de factores para los propósitos de modelado, donde el gran número de variables impide modelar todas las medidas individualmente. Por ejemplo, el análisis factorial se integra en modelos de ecuaciones estructurales (SEM), ayudando a confirmar la variable latente modelada por SEM.
- Para validar una escala o índice mediante la demostración de la carga de elementos constituyentes en el mismo factor.
- Para seleccionar un subconjunto de variables de un conjunto más amplio, basado en qué variables originales tienen mayor relación con los factores de componentes principales.

- Para crear un conjunto de factores a ser tratados como variables no correlacionadas como un enfoque para el manejo de multicolinealidad en los procedimientos de investigación como de regresión múltiple.

El análisis factorial toma como entrada una serie de items o variables. Los que se mueven a la vez se consideran una sola cosa, que se etiquetan como factor.

El Análisis Factorial puede ser exploratorio o confirmatorio. En el análisis exploratorio no se conocen a priori el número de factores y es en la aplicación empírica donde se determina este número. Por el contrario, en el análisis de tipo confirmatorio los factores están fijados a priori, utilizándose contrastes de hipótesis para su corroboración.

En este estudio utilizaremos el análisis factorial exploratorio o Exploratory Factor Analysis (EFA) que trata de descubrir la estructura subyacente de un conjunto relativamente grande de variables. El investigador supone a priori que cualquier indicador puede estar asociado con cualquier factor. Esta es la forma más común de análisis factorial. No existe una teoría previa y se usa cargas factoriales para intuir la estructura factorial de los datos.

La matriz factorial puede presentar un número de factores superior al necesario para explicar la estructura de los datos originales. Sin embargo, hay unos pocos factores que contienen casi toda la información, es decir, que son capaces de explicar la mayor parte de la varianza. En consecuencia, se hace necesario determinar el número de factores que conviene conservar para que haya un porcentaje importante de varianza explicada y se mantenga el principio de parsimonia que debe regir este tipo de análisis. En este estudio utilizamos la Regla de Kaiser para determinar el número de factores utilizados. Esta regla consiste en calcular los valores propios o autovalores de la matriz de correlaciones y tomar como número de factores el número de valores propios superiores a la unidad. Posteriormente comprobamos que el porcentaje acumulado de la varianza explicada alcanza un nivel satisfactorio.

Para comprobar si las características de la matriz de correlación son las más adecuadas para realizar un Análisis Factorial realizamos el Test de esfericidad de Barlett. Este test nos permite determinar si las variables están altamente inter correlacionadas, ya que, si las correlaciones entre todas las variables son bajas, el Análisis Factorial tal vez no sea apropiado.

El Análisis Factorial es adecuado cuando los factores están incorrelados entre sí. Es decir, las correlaciones parciales que son estimaciones de las correlaciones entre los factores únicos deberían ser próximos a cero, ya que en caso contrario, las hipótesis del modelo factorial no son compatibles con los datos. Para evaluar la adecuación de la muestra utilizamos el indicador KMO propuesto por Kaiser, Meyer y Olkin que toma valores entre 0 y 1. Kaise, Meyer y Olkin aconsejan que si KMO > 0,75 la idea de realizar un análisis factorial es buena, si 0,75 > KMO > 0,5 la idea es aceptable y si KMO < 0,5 es inaceptable.

Para interpretar el significado de los factores utilizamos la matriz de cargas factoriales. Si los factores son ortogonales permiten cuantificar el grado y tipo de relación que existe entre los factores y las variables originales. Como los métodos de extracción de factores no suelen proporcionar matrices de cargas factoriales adecuadas para la interpretación debemos acudir a procedimientos de Rotación de Factores que faciliten la interpretación.

Con este tipo de métodos obtendremos una matriz de cargas factoriales donde cada factor presentará una distribución diferente con cargas altas y otras bajas de cada una de las variables y donde cada una de las variables saturará en un factor. De este modo, cada factor presentará una correlación alta con un grupo de variables y baja con el resto.

En este trabajo utilizamos el método Varimax de rotación de factores. Este método minimiza el número de variables con cargas altas en un factor, mejorando así la capacidad de interpretación de factores. Este método Varimax determina la matriz de componentes rotados de forma que se maximice la suma de las varianzas.

Por una regla general en el análisis de confirmación de factores, las cargas deben ser 0.7 o superiores para confirmar que las variables independientes identificadas a priori están representados por un factor particular. Sin embargo, la norma 0.7 es alta y los datos pueden no cumplir con este criterio, por lo que algunos investigadores, en particular con fines de exploración, utilizan un nivel inferior, tal como 0.4 para el factor central y .25 para otros factores (Raubenheimer, 2004). Hair et al. (1998) establece que cargas de 0.6 o superiores son consideradas altas y aquellas por debajo de 0.4 bajas. En cualquier caso, factor de cargas debe ser interpretado a la luz de la teoría y no por los niveles de punto de corte arbitrario. Por tanto, si evaluamos a las características de las variables asociadas a un determinado factor podemos encontrar elementos comunes que permitan identificar y nombrar al factor y darle una denominación que responda a esos rasgos comunes.

Dado que las escalas utilizadas en el análisis factorial no se han validado en estudios anteriores, se debe tener cuidado en evaluar la confiabilidad entre los elementos que componen cada escala (Flynn et al., 1990). Para evaluar la fiabilidad interitem se utilizó el Coeficiente Alfa de Cronbach. Valores de Alfa de 0,70 o superior se consideran para indicar una confiabilidad para las escalas establecidas y 0,60 es aceptable para nuevas escalas (Nunnally 1978, Churchill, 1979).

Una vez determinados los factores rotados, el siguiente paso es calcular los valores de las puntuaciones factoriales de cada uno de las observaciones (empresas) de nuestra muestra. Las puntuaciones factoriales nos permite, además de identificar observaciones (empresas) atípicas y las características de determinados subgrupos de la muestra, sustituir el conjunto de variables originales por los factores obtenidos para su posterior análisis mediante otras técnicas estadísicas (ej. analisis cluster, regresión lineal, regresión logística,…).

4.4. Regresión logística

Una vez extraídas las puntuaciones factoriales realizamos una regresión logística para evaluar el impacto de los factores extraídos previamente en el análisis factorial en el conjunto de variables dependientes que deseamos estudiar.

Los modelos de regresión logística son modelos estadísticos en los que se desea conocer la relación entre una variable dependiente cualitativa dicotómica y una o más variables explicativas independientes, o covariables, ya sean cualitativas o cuantitativas. En nuestro caso las variables independientes utilizadas se corresponden con los factores extraídos en el análisis factorial previo y la variable dependiente dicotómica con las variables relacionadas con la orientación medioambiental. La ecuación inicial del modelo de tipo exponencial nos permite cuantificar la importancia de la relación existente entre cada una de las variables independientes y la variable dependiente. Además, podemos clasificar a los individuos (empresas) dentro de las categorías de la variable dependiente según la probabilidad que tengan de pertenecer a una de ellas.

El impacto de las variables de predicción suele explicarse en términos de ratio de probabilidad (odds-ratio). La regresión logística calcula los cambios el logaritmo de las probabilidades de la variable dependiente y no los cambios en si de la variable dependiente. Predice el valor "1" de la dependiente, utilizando el nivel "0" como valor de referencia. El término indepediente del modelo representa el logaritmo de la probabilidad de la variable depeniente cuando los predictores se encuentran en sus valores medios.

El ratio de probabilidad nos permite evaluar el tamaño del efecto. El ratio de probabilidad del logaritmo natural, e, del exponente de la estimación del parámetro, b, y, para las variables continuas, representa el factor por el cual las probabilidades (evento) cambian cuando se produce un cambio de una unidad en la variable independiente.

Para la estimación de los coeficientes del modelo y de sus errores estándar se recurre al cálculo de estimaciones de máxima verosimilitud. Para este cálculo se recurre a métodos iterativos, como el método de Newton–Raphson. Posteriormente, se comprueba la significación estadística de cada uno de los coeficientes de regresión en el modelo utilizando el estadístico de Wald. El estadístico de Wald contrasta la hipótesis de que un coeficiente aislado es distinto de 0, y sigue una distribución normal de media 0 y varianza 1. La obtención de significación indica que dicho coeficiente es diferente de 0 y merece la pena su conservación en el modelo.

4.5. Modelo de ecuaciones estructurales basados mínimos cuadrados parciales (PLS)

Los modelos de ecuaciones estructurales (SEM) con variables latentes han supuesto un cambio en investigación en muchos aspectos. Con SEM se garantiz el rigor en la validación de instrumentos y pruebas de los vínculos entre los constructos Gefen, Straub, and Boudreau, 2000). Dentro de los modelos de ecuaciones estructurales podemos disntinguir las técnicas basadas en técnicas de covarianza (LISREL) y las técnicas basadas mínimos cuadrados parciales (PLS). En nuestro estudio utilizamos la técnica PLS, que ha sido utilizada por un número cada vez mayor de investigadores de diversas disciplinas: comportamiento organizacional (Higgins *et al.*, 1992), gestión estratégica (Hulland, 1999) y el comportamiento del consumidor (Fornell y Robinson, 1983), entre otras. El método fue diseñado por Wold (1974, 1982, 1985) para el análisis de datos con muchas dimensionales en un entorno de baja estructura y ha sido objeto de varias extensiones y modificaciones. En los artículos de esta tesis se justifica el uso de esta metodología por las siguientes razones:

- Permite la evaluación de modelos de relación causa-efecto de tipo formativo (Diamantopoulos y Winklhofer, 2001).
- Puede ser utilizada para estimar los modelos cuando los tamaños de las muestras son pequeños (Chin y Newsted, 1999).

- Puede evaluar modelos complejos con muchas factores latentes y variables formativas sin conducir a problemas de estimación (Marsh, 1985). El modelado con PLS es metodológicamente ventajoso cuando los resultados CBSEM incorrectos o no convergentes son probables que se produzcan (Krijnen, Dijkstra, y Gill, 1998).

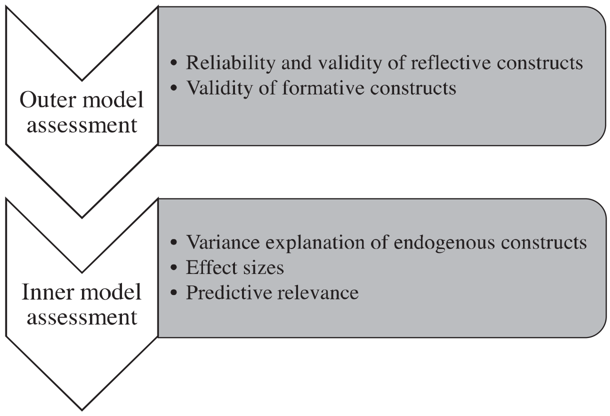
- Puede utilizarse cuando las distribuciones son muy sesgadas (Bagozzi, 1994), o la independencia de las observaciones no está asegurada, ya que no hay requisitos de distribución (Fornell, 1982) .

- PLS es más flexible en cuanto a la escala de medición permitida, ya que se pueden utilizar variables medidas con escalas ordinales e incluso categóricas (Falk y Miller, 1992).

La metodología PLS no proporciona ningún criterio de bondad del ajuste. Chin (1998) propuso unos criterios para evaluar el modelo de forma sistemática en dos etapas. Primero, la evaluación de un modelo exterior y después la evaluación de un modelo interno (figura 4).

La evaluación de modelo se centra primeramente en los modelos de medición buscando determinar la fiabilidad de la medición y la validez de acuerdo con ciertos criterios que se asocian con el modelo exterior. De forma que sólo tiene sentido evaluar el modelo interior cuando las variables latentes muestran fiabilidad y validez. En esta tesis se utiliza SmartPLS que permite estimar en el mismo proceso los parámetros del modelo de medida y del modelo estructural.

Figura 4. Evaluación del modelo PLS en 2 etapas.



Fuente: Henseler *et al.* 2009

Siguiendo las etapas indicadas primero comprobaremos la fiabilidad de las escalas de medida y, posteriormente, evaluaremos el modelo estructural (Hulland, 1999).

En general las escalas de medida pueden ser de tipo reflectivo o formativo y siguen procedimientos de validación diferentes. Para las escalas reflectivas, donde un constructo latente está compuesto por varios indicadores que reflejan un mismo concepto, como ocurre en nuestro caso, se utilizan métodos tradicionales: unidimensionalidad, consistencia, validez convergente y discriminante. En consecuencia, primero analizaremos la fiabilidad de la escala mediante la observación de la fiabilidad de sus correspondientes ítems. Para ello debemos comprobar el signo, la magnitud y la significación de las cargas o pesos obtenidos. De esta forma determinamos si el cada ítem mide, efectivamente, la variable latente a la que ha sido asociado. Por regla general, se consideran adecuados cargas mayores o iguales a 0,7 (Chin, 1998), lo que indica que más del 50% de la varianza es compartida por el constructo.

Después de evaluar la fiabilidad individual de cada indicador, comprobamos la validez convergente y discriminante de los constructos (Barclay *et al.*, 1995).

La validez convergente permite determinar si los diversos indicadores de un constructo miden lo mismo, por lo que se exige que estén altamente correlacionados. Según Nunnally (1978), la consistencia interna medida mediante el alfa de Cronbach (Fornell y Larcker, 1981) debe ser superior a 0,7, para considerar aceptable la fiabilidad de un constructo (Barclay *et al.*, 1995; Chin, 1998; Hair el al., 1999) y la varianza extraída media (AVE) debe ser superior a 0,5. De esta forma podríamos considerar que los indicadores son confiables y que el modelo de medida es aceptable.

Finalmente debemos comprobar si las escalas propuestas están midiendo realmente conceptos diferentes, validez discriminante. Indica en qué medida un constructo es diferente de los otros constructos del modelo. Para ello, cada variable latente debe compartir más varianza con sus indicadores que con otras variables del modelo. El criterio comúnmente utilizado requiere que la raíz cuadrada de la AVE de cada constructo sea superior a la correlación que tiene con el resto de constructos.

En la evaluación del modelo estructural pretendemos, por una parte, determinar en qué medida las variables predictoras contribuyen a la varianza explicada de las variables endógenas o dependientes. Contrastamos las relaciones causales entre los constructos del modelo que vienen determinadas por las hipótesis del trabajo. Para ello examinamos el signo, el tamaño y el nivel de significación de los coeficientes estandarizados (path coefficients) estimados por el modelo. Estos coeficientes representan el efecto de cada variable independiente sobre las variables dependientes. Para determinar si los coeficientes estandarizados son significativos se valora la t de Student de un proceso de bootstrapping o remuestreo con 5000 submuestras obtenidas a partir de la muestra inicial.

Por otra parte, podemos valorar la cantidad de varianza de las variables dependientes que se explica por las variables predictoras. En este caso, analizamos el coeficiente de determinación R^2, que se interpreta igual que en una regresión múltiple. Se considera que las variables predictoras tienen suficiente capacidad predictiva si su coeficiente de determinación, R^2, es superior a 0.1 (Falk y Miller, 1992).

Para finalizar, Chin (1998b) y Tenenhaus *et al.* (2005) proponen medir la relevancia predictiva de los constructos dependientes. Para ello se realiza el Test de Stone-Geisser (Q^2), que consiste en una validación cruzada del modelo evaluando en qué medida los parámetros estimados son útiles para predecir las variables observadas correspondientes a estos constructos. Este test (Stone, 1974; Geisser, 1975) se usa como criterio para medir la relevancia predictiva de los constructos dependientes. Si Q^2 es mayor que cero indica que el modelo tiene relevancia predictiva y se obtiene mediante un proceso de blindfolding obtenemos los valores de Q^2.

4.6. FIMIX-PLS

Los modelos de ecuaciones estructurales son ampliamente utilizados en la investigación empresarial para evaluar las relaciones entre los constructos del modelo y las variables no observadas. La mayoría de aplicaciones suponen que los datos provienen de una población homogénea. Sin embargo, este supuesto de homogeneidad no es realista, ya que los individuos pueden diferir en sus percepciones y evaluaciones de los constructos latentes (Ansari, Jedidi y Jagpal, 2000). Para tener en cuenta la heterogeneidad, los investigadores utilizan con frecuencia procedimientos secuenciales en subgrupos homogéneos que se forman por medio de una información a priori, o bien vuelven a la aplicación de técnicas de análisis cluster. Sin embargo, ninguno de estos enfoques se considera satisfactoria (Wedel y Kamakura, 2000) y, en consecuencia, los esfuerzos de investigación se han dedicado al desarrollo de métodos de agrupamiento basados en modelos (por ejemplo, Jedidi, Jagpal y DeSarbo, 1997).

En la actualidad, los investigadores han propuesto diferentes enfoques para la detección de clases latentes basados en PLS. Sarstedt (2008) presenta una revisión teórica de los procedimientos disponibles y concluye que PLS finitos mezcla (FIMIX-PLS) es ahora la primera opción para tareas de segmentación dentro de un contexto PLS.

Hahn *et al.* (2002) introdujo la técnica FIMIX-PLS para la detección latente clase. El método permite la simultánea estimación de los parámetros del modelo y afiliaciones al segmento correspondiente de observaciones.

Sin embargo, el problema más complejo en la aplicación de FIMIX-PLS es el tema de la selección del modelo (es decir, la determinación de la cantidad de segmentos subyacentes a los datos). Como en cualquier procedimiento de agrupamiento, conservando un número adecuado de segmentos es crucial, ya que muchas decisiones de gestión se basan en este resultado. Una mala especificación puede dar como resultado una sub o sobre-segmentación, lo que conduce a decisiones erróneas de gestión.

El algoritmo FIMIX-PLS permite al investigador calcular varios criterios estadísticos de selección de modelos que son bien conocidos, tales como: criterio Akaike (AIC, Akaike ,1973), Criterio de información bayesiano (BIC, Schwarz, 1978), AIC consistente (CAIC, Bozdogan, 1987), y criterio de entropía (EN, Ramaswamy, DeSarbo, y Reibstein, 1993). Estos criterios nos permiten determinar el número de segmentos de datos que deben ser retenidos.

A partir de la detección de los segmentos y la clasificación de los mismos podemos identificar las diferencias entre las características de los distintos grupos formados.

5. Resúmenes extendidos de los artículos

5.1. A review of the literature on eco-design in manufacturing industry: Are the institutions focusing on the key aspects?

Este artículo consiste en revisar la literatura referente a la aplicación de la estrategia del eco-diseño en la industria, desde el desarrollo del producto teniendo en cuenta el ciclo de vida del mismo analizando como afecta el desarrollo sostenible de productos a la competitividad de la empresa hasta las actuaciones que desde las administraciones públicas se han implantado para fomentarlo.

En los últimos años hemos visto la preocupación cada vez más visible hacia el desarrollo sostenible. Cada sector, deseoso de adaptarse a esta situación, tiene que incorporar el desarrollo sostenible en sus planes de actuación. Detrás de esta orientación estratégica, vemos que no sólo está la economía, sino un deber ético.

Todos los productos tienen un impacto en el medio ambiente en cada una de las fases de su ciclo de vida, considerando que el ciclo de vida comprende desde la extracción de las materias primas hasta su disposición final o su reutilización, pasando por la producción, utilización o transporte.

Mediante el eco-diseño se pretende integrar los criterios medio ambientales en la fase de diseño para reducir el impacto ambiental del producto.

En este trabajo se revisan las principales aportaciones de diferentes autores sobre el concepto eco-diseño y competitividad, así como diferentes casos del efecto del eco-diseño en industrias de fabricación como el calzado, la automoción y componentes electrónicos.

Con la información analizada, podemos concluir que los beneficios de la implementación del eco-diseño están claramente identificados en la literatura, considerando que conllevan una mejora en la competitividad, reducción de costes, mejoran la imagen de la compañía e incluso es considerada como una oportunidad para mejorar el desarrollo del producto.

Por otro lado, cabría señalar que la industria necesita herramientas que les ayuden a alcanzar estos objetivos por parte de las autoridades públicas, pero las administraciones no están centradas en los aspectos clave.

5.2. What is influencing the sustainable attitude of the automobile industry?

Durante mucho tiempo los indicadores que han utilizado las compañías para establecer sus objetivos en el desarrollo del producto han estado basados principalmente en datos económicos sin tener en cuenta aspectos sociales o ambientales.

Compensando esta situación, en 1995 apareció un indicador creado por William Rees llamado la huella ecológica (M. Wackernagel y W. Rees, 1996, Our ecological footprint) que mide el impacto de la actividad humana en el medio ambiente. Hoy en día la humanidad utiliza el equivalente de 1.5 planetas para suministrar los recursos que utilizamos y absorbemos o desperdiciamos. Esto significa que actualmente la Tierra necesita 1 año y seis meses para regenerar lo que utilizamos en un año. Para contrarrestar esta situación es importante establecer un desarrollo sostenible implementando estrategias ambientales en la fase de diseño que permitan reducir el impacto ambiental de los productos tanto durante su ciclo de vida como al final de la misma.

En este sentido, la industria del automóvil, como otras industrias, debe afrontar el desafío de adaptar el diseño del producto y proceso integrando los aspectos ambientales, teniendo como objetivo reducir el impacto ambiental teniendo en cuenta el ciclo de vida completo del producto, respetando a su vez las especificaciones técnicas del producto y proporcionando soluciones con costes de producciones similares al desarrollo tradicional hasta la fecha.

El aumento de la conciencia ecológica ha sido ayudado por la introducción de reglamentación medio ambiental. Los vehículos al final de su vida útil generan una gran cantidad de residuos que deberían ser reutilizados y reciclados. La realización de esta actividad está predefinida especialmente a través de la Directiva 2000/53/EC establecida por el Parlamento Europeo y el Consejo de End of Life Vehicles (ELV). Con el cumplimiento de esta directiva se espera reducir la producción de residuos limitando el uso de sustancias peligrosas en nuevos vehículos, diseñando y produciendo vehículos que faciliten la reutilización y reciclado y desarrollando la integración de materiales reciclados.

Las compañías que trabajan como proveedores de los fabricantes de vehículos son un elemento clave en el diseño de vehículos para reducir el impacto ambiental. Este artículo proporciona una visión general de las implicaciones y limitaciones debido a la integración del eco-diseño en Faurecia, empresa especialista en ingeniería y producción de componentes del automóvil, líder en cada una de sus unidades de negocio: Asientos, Tecnología de Control de Emisiones, Interiores y Exteriores. Las principales líneas de actuación existentes para reducir la huella ecológica se basan en una estrategia de innovación centrada en la reducción de peso, tecnología de control de emisiones y reducción de la huella ecológica desde la producción hasta el final de la vida útil del vehículo.

El objetivo de este estudio es determinar si existen características que diferencien las compañías de automoción en su actitud medioambiental a través del análisis cuantitativo de una muestra de 224 empresas pertenecientes a la industria española del automóvil, teniendo en cuenta cuatro variables:

- Importancia de la reducción de materiales por unidad producida al innovar.
- Importancia de la reducción del consumo energético por unidad producida al

innovar.

- Importancia de la reducción del impacto medio ambiental al innovar.

- Importancia del cumplimiento de la legislación medio ambiental al innovar.

En el artículo se concluye que la proactividad medioambiental viene determinada principalmente por el tamaño de la empresa. De acuerdo a los resultados cuanto mayor es la compañía, cuanto mayor es el número de patentes y cuando la presencia internacional es más extensa, mayor es la orientación medio ambiental al innovar.

5.3. Factors influencing eco-innovation orientation of the automobile firms.

Aceptando su responsabilidad social y medio ambiental, la industria del automóvil debe afrontar el desafío de adaptar el diseño del producto y proceso integrando aspectos medio ambientales (Schiavone *et al.*, 2008).

El primer acercamiento se centró inicialmente en el diseño de vehículos que facilitaran el desmontaje y reciclado de las piezas al final de la vida útil del vehículo teniendo en cuenta la accesibilidad a las piezas a desmontar, el tipo y número de sujeciones utilizados y el marcado de los componentes para facilitar su identificación (Morrison, 2000; Gerrard y Kandlikar, 2007)

Pronto se puso de manifiesto la necesidad de dirigir esfuerzos a incorporar los principios del desarrollo sostenible considerando la vida en servicio del producto e involucrando los proveedores desde las primeras fases del diseño. (Guide y Vand Wassenhove, 2001)

Relativamente poca investigación se ha conducido sobre la conexión entre eco-innovación y eco-diseño y su implicación para la industria del automóvil. Este artículo ayuda a rellenar este gap estudiando qué aspectos relacionados directamente con el eco-diseño han sido tenidos en cuenta al innovar en la industria del automóvil.

La eco-innovación juega un papel importante dado que permite aumentar el valor para fabricantes y consumidores al mismo tiempo que se reducen los impactos medioambientales (Van Berkel, 2007). El campo de la eco-innovación incluye la modificación de patrones de producción y consumo así como el desarrollo de tecnologías, productos y servicios para reducir nuestro impacto en el medio ambiente. (Comisión Europea, 2009)

A pesar de que la innovación ecológica es una tendencia clave en la industria actual, relativamente pocas investigaciones se han realizado sobre su incidencia en el sector del automóvil. En este trabajo, la actitud hacia el medio ambiente cuando se innova se analizó mediante un Modelo de Ecuaciones Estructurales (SEM) aplicada a un conjunto de datos de 224 empresas españolas del sector. Los resultados muestran que las empresas que se centran en los procesos y productos innovadores tienden a ser más ambientalmente orientadas a la hora de innovar. Destacamos asimismo la importancia de las fuentes de información.

Los resultados muestran que las empresas en las que las fuentes de información del mercado (provenientes de proveedores, clientes, competidores y consultores externos) son importantes en el proceso de innovación están más orientadas a la reducción de costes y al desarrollo de nuevos productos y mercados cuando están innovando y, consecuentemente, están más orientadas al medio ambiente.

La consistencia en los hallazgos sugieren que las empresas que buscan una mayor flexibilidad operacional, aumentar la capacidad de producción, reducir los costos laborales por unidad o reducir el consumo de energía por unidad cuando están buscando nuevas innovaciones están más dispuestas a adoptar también una orientación medioambiental, lo que tiene importantes implicaciones para la gestión si una empresa está tratando de ser más "verde".

5.4. Grouping firms attending to their environmental orientation: an empirical study of the Spanish automotive industry

Un tema de investigación de verdadero interés en la actualidad está relacionado con el logro de ventajas competitivas mediante la mejora del compromiso ambiental de las empresas. Hasta ahora, ha habido varios intentos de clasificar a las empresas atendiendo a su orientación hacia el medio ambiente, pero todavía hay un vacío de investigación al abordar el análisis empírico. El propósito de este estudio es identificar los grupos de empresas dentro de la industria del automóvil con diferentes mecanismos a la hora de impulsar su proactividad medioambiental. En el artículo anterior establecíamos el modelo general de elementos que ejercían un impacto significativo en la orientación medioambiental de las empresas del sector del automóvil cuando innovan. Como vimos, la eco-orientación está influida de manera significativa por la orientación a procesos y a productos de la innovación. Asimismo, a través de estas últimas la importancia de las fuentes de información del mercado ejerce una influencia positiva en la orientación medioambiental.

Sin embargo, podemos prever que no en todas las empresas del sector estos mecanismos actúen de igual manera ni con la misma intensidad. En este artículo identificamos grupos de empresas con un comportamiento similar (es decir, los segmentos de empresas), utilizando el algoritmo PLS-FIMIX aplicado a los datos de base de la datos PITEC de 224 empresas pertenecientes a la industria española del automóvil.

Los resultados muestran la existencia de tres grupos de empresas cuya orientación ambiental mientras innovan está determinada de manera diferente. En el mayor grupo de empresas, la orientación hacia el medio ambiente viene determinada en igual proporción por la orientación hacia productos y procesos que muestran estas empresas, es decir, equilibran la orientación interna para mejorar los procesos y reducir el impacto ambiental y el coste y la búsqueda de nuevos productos y nichos de mercado para aprovechar la nueva demanda "verde". En un segundo grupo, la orientación al mercado es la que está impulsando procesos de innovación medioambiental. Finalmente, el último grupo se opone a la tendencia general en estas relaciones y vemos como la orientación hacia productos de la actividad innovadora afecta de forma negativa en la orientación medioambiental de las empresas a la hora de innovar.

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CAPÍTULO 2

A REVIEW OF THE LITERATURE ON ECO-DESIGN IN MANUFACTURING INDUSTRY: ARE THE INSTITUTIONS FOCUSING ON THE KEY ASPECTS?

A Review Of The Literature On Eco-Design In Manufacturing Industry: Are The Institutions Focusing On The Key Aspects?

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Abstract

The aim of this paper is to review the most important literature in relation to the special characteristics of the eco design as part of the innovation portfolio of companies.

Eco design is a methodology that takes into account the environmental condition of products from conception. More than a half of the impacts can be prevented from the design process so that throughout their life circle are less harmful to the environment. As a methodology that integrates environmental criteria in the design of products and services, managing the environmental innovation through eco-design has to be considered as part of the strategic definition of both, companies and Public Agencies.

We pretend to analyze literature related to eco-design in companies and the way policy makers are pretending to reinforce sustainable attitude at the industrial sector. The main objective of this paper is to uncover if there is any relation between what literature indicates companies are doing and what public administration are pretending with its industrial policies, to see if institutions are focusing on their industrial policies and check if they are covering the key.

Keywords: Eco-Design; Sustainability; Industrial Policy; Competitiveness

1. Introduction

The integration of environmental criteria has to be taken into account when taking decisions during the product development process (Brezet and Van Hemel, 1997, Byggeth and Hochschorner, 2006, Fuad-Luke, 2009), in the early stages of product development, to achieve the objective of achieving a greater degree of Sustainability (Karlsson & Luttropp, 2006).

The need to promote the application of eco-design through training programs at the enterprise level and through actions carried out by national agencies has been highlighted in the past (Brezet, 1997, Madge, 1997), however, many companies still not assume that eco-design should be part of their daily activity (O'Hare *et al*., 2010) and should be integrated into their business strategies (Donnelly *et al*., 2006, Gold *et al*., 2010). Organizations need to communicate clearly and efficiently to project teams, as well as to senior management, what the company's goal is by including a section devoted to the impact of projects on environment and sustainability (Petala, 2010) and, in the other hand, it is an striking lack of industrial policy actions promoted by the public agencies in that line (Santolaria *et al*., 2011, Ceschin and Vezzoli, 2010).

This paper reviews the major contributions on the eco-design concept and its actual implementation in the manufacturing industry, following the line of work defined by Sekaran and Boogie (2010), its influence on business competitiveness and actions that, from public agencies, have been implemented to encourage this.

2. Review of the concept and its application

As it is actually understood, the aim of the Eco-design is to reduce the environmental impact of products throughout their entire life. *For Life Cycle* means all life stages of a product, from production of components and raw materials for their production, to disposal of the product once it is discarded, but although this is largely accepted concept both in academic and social level, several definitions are given in the literature, as seen in Table 1.

Table 1. Eco-Design definitions

Author	Definition
Alonso (2006)	Eco design is an approach that integrates environmental criteria in the design of products and services, so as to get the reduction of environmental impacts they produce, taking into account all stages of their life cycle.
Wimmer *et al.* (2004)	Eco design is how to integrate environmental considerations into product design and development.
Borchardt *et al.* (2011)	Eco design is a set of Project practices oriented to the creation of eco-efficient products and processes.
Pigosso *et al.* (2010)	Eco design is a proactive approach of environmental management that aims to reduce the total environmental impact of products.
Plouffe *et al.*, 2011	Eco design means taking simultaneously into account the environmental impacts in the selection of raw materials, the manufacturing process, the storage and transportation phase, usage, and final disposal.
Karlsson and Luttropp, 2006	Eco design is about Design in and for a sustainable development.
Bhamra, 2004	Eco design is understood to be the systematic integration of environmental considerations into the design process across the product life cycle, from cradle to grave.
Platcheck, 2008	Eco design is a holistic view in that, starting from the moment we know the environmental problems and its causes, we begin to influence the conception, the materials selection, the production, the use, the reuse, the recycling and final disposition of industrial products.
IHOBE, 2011	Eco-design means that the environment is taken into account when making decisions during the product development process as an additional factor that traditionally have been taken into account.

Source: Compiled by the authors

An innovative definition was made by Karlsson and Luttropp (2006), highlighting the linkages between social, economic, and environmental business in the eco-design linguistic map (see figure 1).

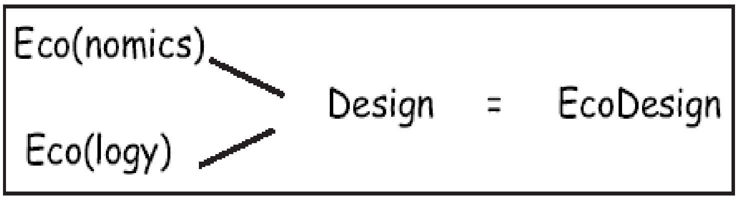

Figure. 1. Linguistic map of ''Eco-Design'' (Karlsson and Luttropp, 2006)

3. Eco-design and competitiveness

Several authors state competitiveness is a very localized process, based on groups of firms organized around one o several related industries that converge (Porter, 1985, 1998, Grant, 1996, Mintzberg and Lampel, 1999). Others state that a firm's strategy should be based on its resources and internal capabilities, and that these factors prevail over the market (Grant, 1996).

In accordance with Grant (1996), firms should be competitive basing their strategy on endogenous factors. A firm's capability of response requires deep knowledge about the environment; but also about the management's function and up to which degree the organization's culture affects the firm's profitability and return. A successful use of eco-design tools not only requires the availability of appropriate tools, but also a real integration of eco design within the business operations (Dewulf and Duflou, 2004).

The resources and capabilities approach (Wernerfelt, 1984, Peteraf, 1993, Hamel and Prahalad, 1994) arises as a reinterpretation of the firm's environment, introducing the firm's internal organizational system, as aspects to take into account when considering the causes of a firm's profitability. In this line, Plouffe *et al.* (2011) disentangle the existing relations among internal aspects related to the company, the eco design concept, understood as a new philosophy and the economic aspects it represents.

Although environmental issues as seen as external to the company as Karlsson and Luttropp, (2006) remark, these two approaches, the external or environmental and the internal one have been focused as different alternatives for the study of the eco design integration, other authors think they complement each other (Dewulf and Duflou, 2004).

The globalization process of economy has modified the productive activity, enhancing the level of rivalry among firms which generates an immediate reaction in order to respond successfully to this new situation: the necessity, for the industrial sector in a specific area, to keep a high level of competitiveness, but actually spells out the role played by the environment, the institutions, and the economic policies of a country in the competitive success of some industries, considering environmental proactivity and, indeed, eco design a key differentiating asset (Wimmer *et al.*, 2010). Going behind the product's end-of-life is important to reduce the environmental impact of the product's final disposal and this is actually a key differentiating competitiveness aspect to focus on (Pigosso *et al.*, 2010, Schiavone *et al.*, 2008).

Stage 1 Viewing Compliance as Opportunity	Stage 2 Making Value Chains Sustainable	Stage 3 Designing Sustainable Products and Services	Stage 4 Developing New Business Models
Central Challenge To ensure that compliance with norms becomes an opportunity for innovation. **Competencies Needed** - The ability to anticipate and shape regulations. - The skill to work with other companies, including rivals, to implement creative solutions. **Innovation Opportunity** - Using compliance to induce the company and its partners to experiment with sustainable technologies, materials, and processes.	**Central Challenge** To increase efficiencies throughout the value chain. **Competencies Needed** - Expertise in techniques such as carbon management and life-cycle assessment. - The ability to redesign operations to use less energy and water, produce fewer emissions, and generate less waste. - The capacity to ensure that suppliers and retailers make their operations eco-friendly. **Innovation Opportunities** - Developing sustainable sources of raw materials and components. - Increasing the use of clean energy sources such as wind and solar power. - Finding innovative uses for returned products.	**Central Challenge** To develop sustainable offerings or redesign existing ones to become eco-friendly. **Competencies Needed** - The skills to know which products or services are most unfriendly to the environment. - The ability to generate real public support for sustainable offerings and not be considered as "green-washing." - The management know-how to scale both supplies of green materials and the manufacture of products. **Innovation Opportunities** - Developing compact and eco-friendly packaging.	**Central Challenge** To find novel ways of delivering and capturing value, which will change the basis of competition. **Competencies Needed** - The capacity to understand what consumers want and to figure out different ways to meet those demands. - The ability to understand how partners can enhance the value of offerings. **Innovation Opportunities** - Developing new delivery technologies that change value-chain relationships in significant ways. - Creating monetization models that relate to services rather than products. - Devising business models that combine digital and physical infrastructures.

Figure. 2. Sustainability Challenges, Competencies, and Opportunities (Nidumolu *et al.*, 2009)

The definition of competitiveness has been evolving along time. Cohen, Teece, Tyson and Zysman (1984) affirm international competitiveness is based on productivity and, therefore, on an economy's ability to move products towards activities with a higher productivity and a focus on the existing heterogeneity among firms belonging to the same industry. Firms are pools of unique resources and capabilities, which are the basis of competitive advantages (Penrose, 1959, Wernerfelt, 1984, Barney, 1991, Peteraf, 1993), actually, those aspects related to environmental issues, and specially those tied to eco design as cost reduction, new market and new products launches (Borchardt *et al.*, 2011) are becoming key issues that not only depend on business challenges (Nidumolu, 2009), and that affect the opportunities detection and the new business development process (see figure 2), and it is also a society's demand (Hull and Rothenberg, 2008, Auger *et al.*, 2010) and a public statement's (Faber and Frenken, 2010, Juntti *et al.*, 2008, Holzinger *et al.*, 2008).

4. Industrial policy and eco-design issues.

Even at the media era, we still have to consider that proximity and the informal social net facilitates the transfer of specific; technological knowledge (Aufdretsch y Feldman, 1996, Baptista y Swan, 1998), knowledge about the clients' preferences (Von Hippel, 1988), and about the processes (Helper, 1990, Saxennian, 1996), and that all these variables, actually considering also proactive orientation (Segarra *et al.*, 2011) and eco design (Santolaria *et al.*, 2011) take part in the competitive positioning of a company. Public environmental policy is able to affect, at least partly; technology, market conditions and the regulatory framework while company internal conditions and aspects are not easily directly influenced by public policy (Rubik, 2001).

Del Río *et al.* (2010) elaborated an integrated policy framework, including policy features and specific measures that can be implemented to mitigate the barriers to eco-innovations that companies usually face. In their opinion, a combination of environmental and technology policies adapted to the different barriers and characteristics of the technologies could reinforce isolated companies actions.

Considering that, at the academia level, it is argued that policy learning occurs despite, rather than because of the instrumental design of the new assessment procedures, which tends to act as a barrier to open deliberation and knowledge utilisation (Hertin *et al.*, 2009), some industries tend to leader the eco design process at the last decade.

5. Manufacturing industries case studies.

Scientific literature has identified several distinctive features about the effect that eco design has on industries. Borchardt *et al.* (2011) studied the eco design application in the footwear industry in Brazil, using case study. They observed a 10% cost reduction, the toxic materials were eliminated and also noticed a reduction of energy consumption. In the same type of study, Schiavone *et al.* (2008) concluded that the automotive industry needs for extended environmental analysis as an information source in order to identify the best-performing design solutions.

O´Hare *et al.* (2010) found that the electrical and electronic British equipment industry need better suit their needs and that the current understanding of designers requirements for eco-design tools may not be directly applicable. In the same line, Dewulf and Duflou (2004) concluded that sector-wide initiatives can provide incentives for a wider application of eco-design in today's companies.

Other authors that have studied specific aspects of the application of eco design, Platcheck *et al*., (2008), focuses on the need of having a responsible industrial administration, where all involved in the process will have obligations with the sustainability.

6. Conclusions.

This study focused on eco design in manufacturing industry and the needs that companies have when considering the improvement of their environmental performance through eco-design. Benefits from the eco design attitude and implementation have been clearly identify in the literature review, as competitiveness improvements, cost reduction, better company image or new product development, but what several researchers have pointed out is that industry need supporting tools for achieving eco design goals.

Being eco design an emerging field for both research and practice, which aims to help organizations to obtain better performance, decisions of public authorities are going behind the corporate actions, though the institutions are not Focusing On The Key Aspects.

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CAPÍTULO 3

WHAT IS INFLUENCING THE SUSTAINABLE ATTITUDE OF THE AUTOMOBILE INDUSTRY?

What is influencing the sustainable attitude of the automobile industry?

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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.

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 one year and six 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 8 and 9 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).

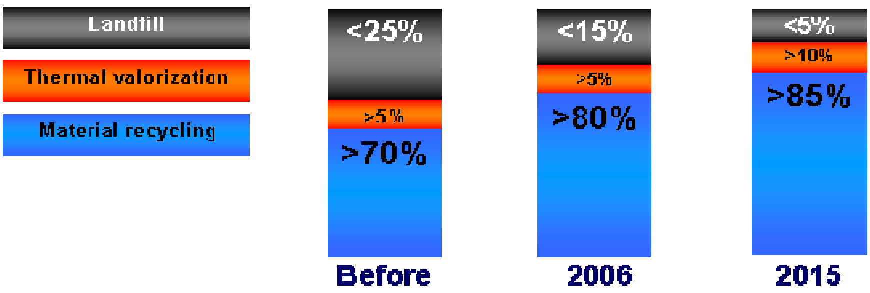
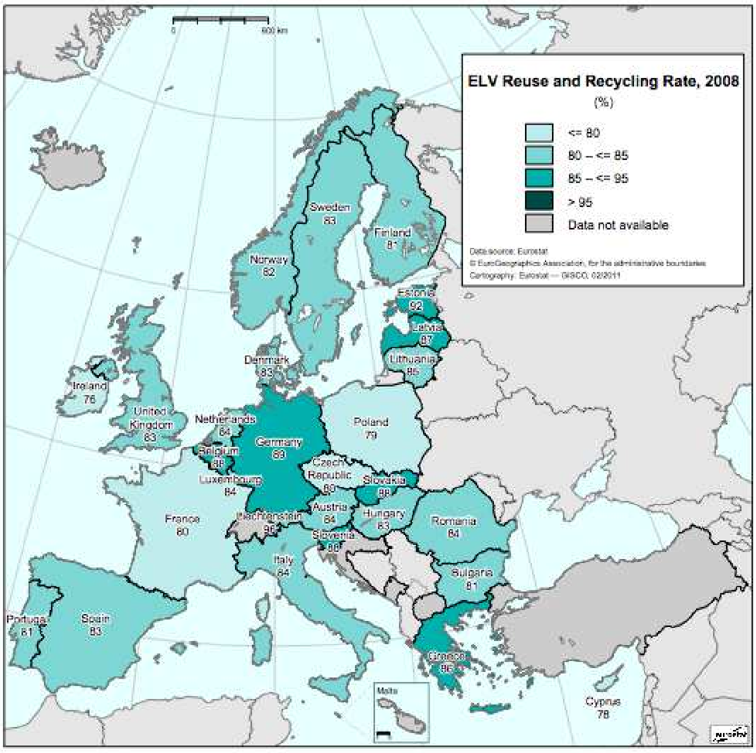


Fig. 1. Reuse and recycling rates.

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 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.



Source: Eurostat

Fig. 2.ELV reuse and recycling rate in 2008 in EU.

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, 4 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 to 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 to 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 3 main options of recycling. According to these 3 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 1, 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 3 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)

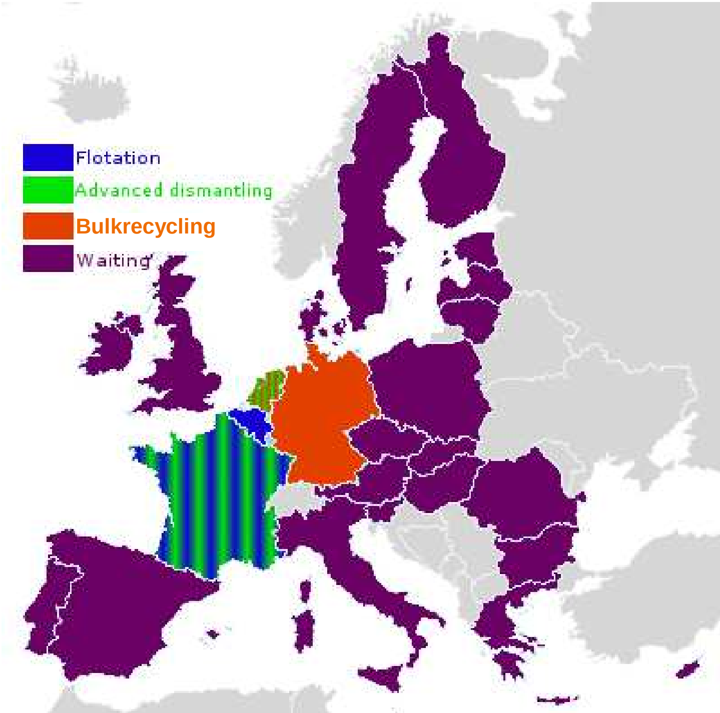


Fig. 3. Recycling technologies available in Europe per member.

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.

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 4 iterations. * Principal Component analysis. Varimax with Kaiser Normalization. 78,963% variance explained -KMO ,756- Sig .000

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).

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 .6 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 1983, 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 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 0 and a standard deviation of 1.

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 “1” value of the dependent, using the “0” level as the reference value.

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.

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< .05

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.

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CAPÍTULO 4

FACTORS INFLUENCING ECO-INNOVATION ORIENTATION OF THE AUTOMOBILE FIRMS.

Factors influencing eco-innovation orientation of the automobile firms.

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Abstract

Even though eco-innovation is a key trend in industry today, relatively little research has been conducted on its implication for the automobile industry. In this paper, the attitude toward environment when innovating is analyzed using the SEM (Structural Equation Model) technique, applied to a data set of 224 Spanish companies. Results show that companies that are focused on processes and products when innovating tend to be more environmentally oriented when innovating and highlight the importance of information sources. Results show that companies where market information sources (coming from suppliers, clients, competitors and external consultants) are important in the innovation process are more oriented to cost reduction and to the development of new products and markets when they are innovating and, subsequently they are more environmentally oriented. The consistency in findings would suggest that companies that look for more operational flexibility, to increase production capacity, to reduce labor costs per unit or to reduce energy consumption per unit when they are looking for new innovations are more willing to adopt an environmental orientation too, what has important managerial implications if a firm is trying to go greener.

Keywords: eco-design, eco-innovation, automotive industry, environment orientation.

1. Introduction.

Accepting its social and environmental responsibility, the automotive industry must face the challenge of adapting its strategy to environmental requirements (Sullivan, 2002, Schiavone et al., 2008), as the industry confronts environmental issues related to vehicle emissions, non-renewable material and energy consumption, and generation of waste during production (Nunes and Bennett, 2010; Deif, 2011). There is increasing stakeholder awareness reflected in more restrictive legislation and higher customer requirements (Manzini and Vezzoli, 1998). Due to the wide range of environmental impacts of the automotive industry, a variety of sustainability strategies, defined as choices available to managers to align environmental and social investments with the generic strategy of the company (Orsato, 2009) have been launched to rectify this situation (González et al., 2008). These strategies follow basic statements defined by the "designing for environment principles" (Suh, 1990) and the "green design approach" (Zuburtikudis, 2001) that emphasized the basis for approaching sustainable development in manufacturing as well as stressing its competitiveness aspect (Pigosso et al., 2010; Schiavone et al., 2008).

A key recommendation of those precepts in the automotive industry is that waste generation must be avoided as much as is possible (Santini et al, 2011, Ferrão and Amaral, 2006).

Also the increase of ecological awareness has been supported by the introduction of environmental legislation (Ferrão and Amaral, 2006), especially due to directive 2000/53/EC, established by the European Parliament and the Council of End of Life Vehicles (ELV). Its aim is to improve the environmental performance of all economic operators involved in the lifecycle of vehicles by reducing residue production, limiting the use of hazardous substances in new vehicles, designing and producing vehicles that facilitate reusing and recycling, and by developing the integration of recycled materials (Gerrard and Kandlikarb, 2007, Gross, 2008, OECD, 2008).

That is why eco-innovation, that basically considers any innovation which reduces damage to the environment (Kanerva et al., 2009) is an emerging field that aims to help organizations improve their environmental performance (Bhamra, 2004) and becomes crucial in ensuring, on one hand, profitability of companies (Porter and van der

Linde, 1995; Pujari, 2006; Orsato and Wells, 2007; Ambec and Lanoie, 2008) and, on the other hand, their managerial strategy´s orientation (Segarra et al., 2011a).

To date some authors have devoted their research to the environment and its application in the automobile industry (Keoleian, 1993, 1997; Geffen and Rothenberg, 2000) but relatively little research has been conducted on the connection between environment eco-innovation and its implication for the automobile industry. This paper aims to help fill this gap.

2. Literature review and hypotheses' statement.

Eco-innovation plays a central role in moving toward a sustainable economy and society, since it allows for increasing the value for producers and consumers while reducing environmental impacts (Van Berkel, 2007). The eco-innovation field not only includes the modification of patterns of production and consumption but also the development of technologies, products and services to reduce our impact on the environment. Several authors have defined it: Huppes et al. (2008) as a change in economic activities that involves a performance improvement in social, economic and environmental aspects; Kemp and Pontoglio (2011) as the production, assimilation or exploitation of a product, production process, service or method of management or business that is new to the organization (developed or adopted) and which implies a reduction of environmental hazards, pollution and other negative impacts of resource use (including energy) during their life cycle compared to the corresponding alternatives.

There are several studies along these lines that apply to the automobile industry. Aragón-Correa et al. (2008) studied the car spare parts sector, concluding that the companies with the most environmentally proactive practices had a better economic performance. Simpson et al. (2007) studied the automotive supply chain in Australia supporting the importance of asset-specific investments in the relationship between a customer´s environmental performance requirements and the potential to improve the supplier´s environmental responsibilities. Smith and Crotty (2008) analyzed how the environmental regulations drive eco-innovation in the UK automotive industry. Zhu et al. (2007) identified internal and external drivers to implement green supply chain management systems among Chinese automobile companies. González-Torre et al. (2009) studied the Spanish automotive industry from a reverse logistic focus, remarking the importance of external and internal barriers for implementing it.

However, going one step further to determine the potential drivers of eco-innovation and how those drivers work has not been studied regarding the automotive industry until date. .

3. Hypotheses development

Process oriented companies are defined as those companies that are oriented to cost reduction, and to the increase of capacity and flexibility. Process oriented companies will focus on materials, energy and water saving as this will reduce product costs. Moreover, they will be focused on the increase of the efficiency of their processes which is also cost related. Albors and Hervás (2011) found perceived factors, including benefits and cost savings, are important to innovation adoption in organizations. Then, we can expect that Process Oriented companies, which are looking for cost and operational efficiency, to be simultaneously looking to reduce impact and to improve their environmental performance, that is, to be environmentally oriented.

H1: The Process Orientation has a positive effect on the environmental orientation of the automotive firms while innovating.

Automotive industry is under pressure to be green, especially due to their customers' increasing demand. But far from being a threat, environment awareness should be considered as an opportunity regarding studies that relate competitiveness improvement and differentiation (Vastag et al., 1996, Enz and Siguaw, 1999, Ferrari et al., 2010). Automotive firms have to consider the variables that affect the decisions taken by their clients as they need to create value-added products in order to acquire and loyal clients. On the other hand, product oriented companies are those companies that focus on increasing the quality or the number of products, to penetrate in new markets or to increase market share. Thus, green niche represents a big and increasing market gap to tap into and which cannot be ignored. We can expect that automotive companies that are focusing on their product or service are more likely to be environmentally oriented, as they will try to reach green customers.

H2: The Product Orientation has a positive effect on the environmental orientation of the automotive firms while innovating.

Worldwide managers are considering improving their sustainable operations from the operational-managerial perspective but also from the client´s perspective. Nevertheless, it remains unclear which real actions influence the clients decisions towards the firm’s environmental orientation (Delmas and Toffel, 2004,). Eco-labels and environmental certifications can lead to enhanced customer awareness of companies’ environmental efforts and act as differentiating asset over those that do not engage in eco-certification schemes (Peiró-Signes et al., 2011). Further, competitor’s attitude to environmental aspects might condition firm’s environmental behavior. On the other side, the higher cooperation and more intense relationship that eco-innovative firms establish with suppliers, sharing resources and knowledge and putting the absorptive capacity into value, are characteristics that should be considered to achieve greater competitiveness (Hervás and Albors, 2008).

Then, we can expect that those automotive firms that rely on the market information sources that is, the information from customers, suppliers, competitors and external consultants, are more likely to be environmentally oriented. We can expect here a mediating effect of both, process and product orientation, in this relation. Automotive firms which consider important the market information will be more sensible to the market demands to reduce water, energy and waste consumption and to increase operational efficiency (Process orientation). Moreover, they will be more sensible to the “green” demand of their customer or to the “green” actions of their suppliers or competitors. Consequently, we hypotethize that:

H3: The importance of the market information sources in the innovation process affects positively to the Product Orientation of the automotive companies.

H4: The importance of the market information sources in the innovation process affects positively to the Process Orientation of the automotive companies.

4. Methodology.

The Spanish Technological Innovation Panel (PITEC) is a statistical instrument for studying the innovation activities of Spanish firms over time. The data base is being carried out by the INE (The Spanish National Statistics Institute), which counts on advice from a group of university researchers and the sponsorship of FECYT (Spanish foundation for science and technology. www.fecyt.es) and COTEC (Technological innovation foundation. www.cotec.es). PITEC is designed as a panel data survey to estimate the changes over time of the innovation activities. A set of variables are subjected to anonymization in order to avoid the disclosure problem. Anonymization in this study only affects to the segmentation done to get our sample. Original 4-digit NACE codes is replaced with a 44-industry breakdown. We use the variable *ACTIN* (Economic activity code) to select data from the automotive industry.

We used the last dataset available (2010) to analyze a total of 224 firms belonging to the automotive industry that are included in the database. We disregarded those cases with a lack of data in the variables used in the study.

We chose, attending to theoretical implications, 22 variables (represented in exhibit 1) to characterize these firms.

Exhibit 1. Selected variables from PITEC database

PITEC Variables	Function type	Explanation
$FUENTE_i$ (i=1,…,10)	Cat.	Importance of information sources while innovating (1-internal sources, 2-supliers, 3-clientes, 4-competitors, 5- external consultants, 6-universities, 7-public research institutions, 8- Research institutes, 8-conferences, industrial fair, 9-scientific journals, 10- industry associations)
$OBJET_i$ (i=1,..,10, 12)	Cat.	Importance of the objective "n" while innovating (1.- increase offered number of products or services, 2.- Old product substitution, 3.- new markets penetration, 4.-increase market share, 5.- increase quality, 6.-increase production flexibility, 7.- increase production capacity, 8.-labor cost reduction (per unit) 9.-material cost reduction(per unit), 10.-energy cost reduction(per unit), 11.- reduce environmental impact, 12.-increase employees health and security, 13.- environmental, health and security regulatory

Categorical variables: 1=High; 2=Medium 3= Low 4=Not considered or not important.
F1 is defined as internal information sources, F2-F5, are defined as market sources, F6-F8 as government sources, F9-F10 other external sources.
O1-O5 are defined as product oriented objectives, O6-O10 as process oriented objectives, O11-O13 as other types of objectives.

As we are dealing with latent constructs, covariance structure analysis needs to be undertaken with the use of structural equation modeling in which a priori theoretical knowledge is incorporated into empirical analysis (Tenenhaus et al., 2005)

We used a Partial Least Squares (PLS) approach with SmartPLS 2.0 to analyze the data. We consider this approach appropriate for the following reasons. First, this study is more exploratory than confirmatory, which is a strength of PLS (Leimeister et al., 2009). Second, it requires no presupposition of normality in variables and is geared to research models that predict the effects of some variables on others. Third, we can resample the initial data set and enlarge it, thereby the sample size required is smaller. Finally, SmartPLS 2.0 is able to evaluate the reliability and validity of the instrument simultaneously. Further, This choice is supported by papers such as Anderson and Gerbing (1988), Bagozzi and Yi (1988), Barclay et al. (1995) and Chin et al. (2003), who recommend it over maximum likelihood techniques in studies in which the theory is not firmly established.

We used item reliability internal consistency, and discriminant validity (Chin, 1998) to test the reliability and validity of the research instrument. First, we used individual item loadings to evaluate individual item reliability. According to Chin (1999), individual items with loadings greater than 0.7 are considered acceptable, implying the item explained about 50% of the variance in a specific measure and ensured that the items in the measurement model measured the same construct. Weak loadings are frequently observed in empirical research, especially when newly developed scales are used (Hulland 1999). However, reflective indicators should be eliminated from measurement models if their loadings within the PLS model are smaller than 0.4 (Hulland 1999). Results of item reliability indicated that all items exceeded the threshold, indicating that the survey instrument was sufficient for measuring each construct individually.

Second, we used Cronbach's alpha to evaluate the internal consistency for each construct. The minimum acceptable alpha level is 0.7 for each item loading (Bernstein and Nunnally, 1995). Results show the constructs had values greater than the minimum threshold of 0.7. The loadings for each item and constructs are presented in Exhibit 2.

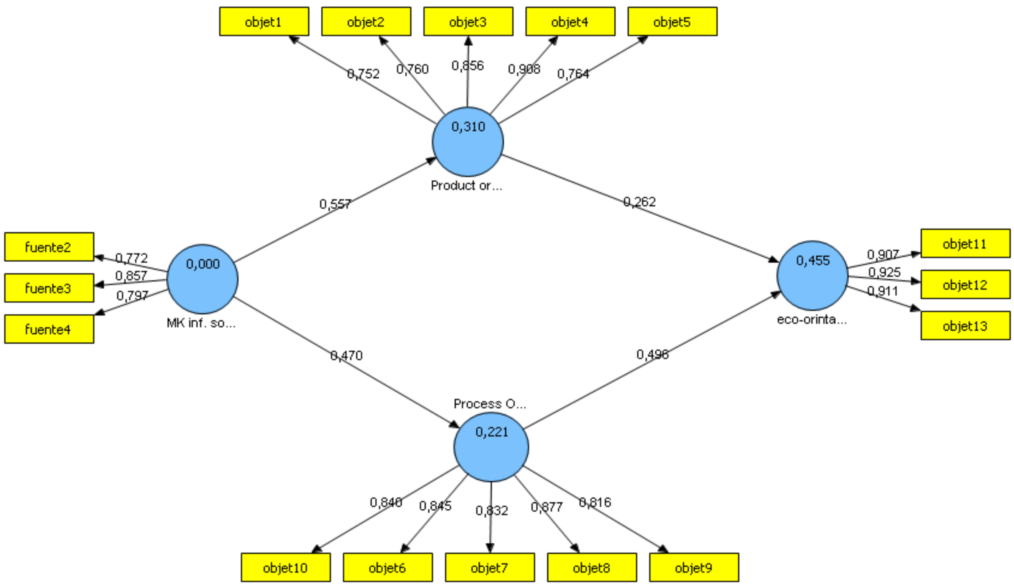
Third, we tested discriminant validity using the average variance extracted (AVE). Discriminant validity is the lack of a relationship among measures which theoretically should not be related. The AVE measures the variance captured by the indicators relative to the measurement error, which should be greater than 0.5 in order to justify the use of a construct (Fornell and Larcker, 1981, Chin, 1999). Further, the latent variables should not exceed the AVE to justify the discriminant validity.

Finally, following Barclay et al. (1995), Tenenhaus et al. (2005) and Henseler et al. (2009) propositions, we consider that this analysis should be strengthened with the cross-validated redundancy index (Q^2) or Stone-Geisser test (Stone, 1974; Geisser, 1975). The Stone-Geisser test gives us a measure of goodness with which the values observed are reconstructed by the model and its parameters (Chin, 1998); it is generally accepted that a model has predictive relevance when Q^2 is greater than zero (Hensler et al., 2009). Q^2 can be measured utilizing procedures of the blindfolding type (Tenenhaus et al, 2005) and is only applicable to latent variables that are incorporated in a reflective measurement model (Henseler, 2009), as in our model.

5. Results and discussions.

The structural model proposed to test our four basic assumptions was estimated by the partial least squares method, using the application SmartPLS 2.0.M3 by Ringle et al. (2005), the results of which are set out in Exhibit 2 below. Exhibit 2 shows (observable) questionnaire items from PITEC database in rectangles and unobservable latent factors with circles. The arrows indicate regression relationships, showing the relationships of items with latent factors (measurement model) and between latent factors (structural model). Corresponding partial regression coefficients are indicated next to the arrows and, inside the circles corresponding to endogenous variables, the coefficient of determination for the corresponding regression.

Exhibit 2. Estimated structural equation model



Results show that companies where market information sources (coming from suppliers, clients, competitors and external consultants) are important in the innovation process are more oriented to cost reduction and the development of new products and markets when they are innovating and, subsequently they are more environmentally oriented when innovating.

The results obtained for the sub-model bear out the choice of indicators. This outcome also constitutes a measure of the validity of the questionnaire used to capture the five latent dimensions. The usual goodness of fit measure, proposed in Tenenhaus et al. (2005), is the geometric mean of the average communality (outer model) and the acceptable average R^2.

As to the reliability of the instrument of measurement, the Cronbach’s alpha value for all the latent variables is greater, as shown in exhibit 3. The composite reliability indices are also greater than 0.5 in all cases.

Exhibit 3. Reliability measurements

	AVE	Composite Reliability	R Square	Cronbachs Alpha	Communality	Redundancy
MK inf. sources	0.655	0.851		0.737	0.655	
Process Orientation	0.709	0.924	0.220	0.897	0.709	0.156
Product orientation	0.657	0.905	0.310	0.868	0.657	0.204
eco-orientation	0.836	0.939	0.455	0.902	0.836	0.322

As regards convergent validity (AVE), the values of the four constructs are near to or greater than 0.5, as recommended in Fornell and Larcker (1981). Likewise, the cross-loads are always greater for the latent variables on which the respective items are loaded. The discriminant validity criterion (Fornell and Larcker, 1981, Hair, 1998) is also met; as for the four latent variables, the corresponding AVE is greater than the square of the estimated correlation between them:

Exhibit 4. Matrix of correlation between latent variables

	MK inf. sources	Process Orientation	Product orientation	eco-orientation
MK inf. sources	**0.809**			
Process Orientation	0.470	**0.842**		
Product orientation	0.557	0.537	**0.811**	
eco-orintation	0.529	0.637	0.529	**0.914**

Note: Square root of AVE on diagonals in bold.

Regarding the structural sub-model, as shown in exhibit 4, the R^2 coefficients associated with latent variable regressions are significant, with values greater than 0.1 obtained in all cases (Falk and Miller, 1992). An analysis of overall effects, shown in exhibit 5, highlights the dependence existing between the latent variables and tends to confirm the initial hypotheses for the model.

Exhibit 5. Direct and overall effects between latent variables

	Process Orientation	Product orientation	Eco-orientation
MK inf. sources	0.470	0.557	0.379
Process Orientation			0.496
Product orientation			0.262

To confirm the theoretical assumptions, exhibit 6 shows the regression coefficients between latent factors, their t-statistics and p-values, estimated by bootstrapping with 5000 samples. The seven proposed relations have significant values, confirming the five basic hypotheses in their various concretions.

We used the structural model to test the independent relationship among the variables proposed in this study. The structural model indicates how well the structural model predicts the hypothesized relationships. We evaluated the strength of the causal relationships between the constructs calculating the path coefficients or standardized betas. Exhibit 2 illustrates support for positive relationships for the proposed hypotheses. The individual path coefficients of the PLS structural model can be interpreted as standardized beta coefficients of ordinary least squares regressions. Structural paths, whose sign is in keeping with a priori postulated algebraic signs, provide a partial empirical validation of the theoretically assumed relationships between latent variables. Exhibit 2 show positive path coefficients in the entire model proposed which confirm directionality of the relationships. The importance of Market Information Sources in firms' innovation is positively related to both Product and Process Orientation while Innovating (β= 0.557, $p<0.001$ and β= 0.470, $p<0.001$ respectively), therefore H3 and H4 were supported.

In regards to the Environmental Orientation construct, results show both variables, Product and Process Orientation while innovating contributed to a significant positive effect on Environmental Orientation. In other words, both Product Orientation ($\beta = 0.262$, $p < 0.05$) as well as Process Orientation (0.496, $p < 0.001$) were found to be significant. Therefore, H1 and H2 were supported.

On the other hand, to confirm our research model we used the squared multiple correlation (R^2) for each endogenous variable. The value of R^2 measures the percent of variance explained by each construct in the model. The independent construct representing the Importance of Market Information Sources in firm's innovation explained 31 % of the variance in Product Orientation. In addition, this construct explained 22.1% of the variance in Process Orientation. Finally, Product and Process Orientation explained 45.5% of the variance in Environmental Orientation. Exhibit 2 shows the standardized path coefficients and variance explained.

Exhibit 6. Tests of hypotheses for direct effects between latent variables

	Total effects	Standard Error	T Statistics
MK inf. sources -> Process Orientation	0.470	0.094	4.983****
MK inf. sources -> Product orientation	0.557	0.079	7.034***
MK inf. sources -> eco-orientation	0.379	0.073	5.193***
Process Orientation -> eco-orientation	0.496	0.094	5.299***
Product Orientation -> eco-orientation	0.262	0.106	2.530**

* Significant values at the 5% significance level.
** Significant values at the 1% significance level.
***Significant values at the 0.1% significance level.

Exhibit 6 shows the Stone-Geisser test (Q2) utilizing blindfolding procedure. Results show that the model has predicted relevance, as Q2 results for each construct are greater than cero.

6. Conclusions.

The purpose of this study was to identify some of the driving forces behind the environmental orientation of the automotive companies. Specifically, this research proposed the importance of the market information sourcess (coming from suppliers, clients, competitors and external consultants) to effectively orientate product and process improvements as the key factors in determining the environmental orientation of the automotive industry firms. Using SmartPLS 2.0 software package, the measurement model was confirmed with sufficient reliability and validity for all of the constructs in the research model. Further, the structural model demonstrated that all of the path coefficients were statistically significant.

The results of our study are consistent with our prior research (Segarra-Oña et al., 2011b) in that eco-innovation activities are positively related to innovation. Companies that are focused on processes and products when innovating tend to be more environmentally oriented when innovating. The consistency in findings would suggest that companies that look for more operational flexibility, to increase production capacity, to reduce labor costs per unit or to reduce energy consumption per unit when they are looking for new innovations are more willing to adopt an environmental orientation too.

On the other hand, firms focused on new products, on increasing or substituting product range, on increasing product quality or on reaching greater market share or new markets, are also more likely to be environmentally orientated.

We tested the importance of companies´ environment (suppliers, clients and competitors) on the innovative orientation and subsequently on the environmental orientation. Hypotheses 3 and 4 assessed the relationship between the importance of the market information sources and the process and product orientation when innovating. Both hypotheses were supported suggesting that organizations that rely importantly on market information sources to innovate are more likely to focus on process and product innovation and, therefore, are more likely to be environmentally oriented. This findings are also supported by Mondéjar-Jiménez et al (2010) who reported that the greater the influence of stakeholders on environmental decisions, the higher the environmental orientation of the firm.

This approach clarifies the most important aspects to be considered while encouraging firms' environmental orientation. It seems that innovation promotion will definitely lead to promote environmental orientation. Environmental aspects are permeating firms' cultures. Innovation activities seeking energy savings, material savings or improved products are uncovering the change firm' new innovation guidelines.

The limitations of this study are basically due to the restrictions of the database. As future actions we propose to analyze in greater depth the factors that hinder or facilitate eco-innovation at internal and external level of the company, as well as the influence of legislative measures such as the IPPC directive or the directive on emissions trading. Therefore, it will be necessary to carry out more detailed qualitative studies as well as implement the study to other countries where the automobile sector has a similar preponderance (e.g. France or Germany) and to compare the results.

Finally, for the practicing engineering manager, who may be responsible for conducting the greening of the innovation related activities; this research highlights the variables that should be considered in their effort to be more oriented to the environment as the paper highlights what are key elements to lead companies from innovation towards eco-innovation and learning from this study will help managers to take the proper decisions.

For instance, engineering managers should be aware of that the identification of the factors presented above, that provided valuable information and may contribute to improve the effectiveness of the investment that companies do in sustainable and eco-innovative areas.

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CAPÍTULO 5

GROUPING FIRMS ATTENDING TO THEIR ENVIRONMENTAL ORIENTATION; AN EMPIRICAL STUDY OF THE SPANISH AUTOMOTIVE INDUSTRY.

GROUPING FIRMS ATTENDING TO THEIR ENVIRONMENTAL ORIENTATION: AN EMPIRICAL STUDY OF THE SPANISH AUTOMOTIVE INDUSTRY

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Abstract

An actual research topic relays on the achievement of competitive advantages by enhancing the environmental commitment of companies. Until now, several attempts to classify companies attending to their environmental orientation have been made but there is still a gap research when addressing empirical analysis. The purpose of this study is to identify groups of companies within the automotive industry with different mechanisms driving their environmental proactivity. We identify groups of firms with similar behaviour (that is, firms segments) using the FIMIX-PLS algorithm applied to data from PITEC database of 224 firms belonging to the Spanish automotive industry and results show that three different groups of companies which environmental orientation while innovation is driven differently. The biggest group of companies orientate towards environment balancing the internal orientation to improve processes and reduce environmental and cost impact and searching for new market products and niches to tap on the new green demand, in a second group, market orientation is pushing harder than processes to orientate companies environmental innovation activity. Finally, the last group is opposing the general tendency in those relations, so this group innovative activity towards the market is acting negatively in the environmental orientation of the firms when innovating.

Key words: *environmental proactivity, environmentally orientation drivers, Spanish automotive industry, sustainable behavior.*

1. Introduction

Several authors (Sullivan, 2002; Schiavone et al., 2008) already pointed out the necessity for automotive industry to align its strategy to environmental requirements. Vehicle emissions, non-renewable material, energy consumption, and generation of waste during production (Nunes and Bennett, 2010; Deif, 2011) are just some of the environmental issues on the table right now. Stakeholder awareness has been pushing legislation (Manzini and Vezzoli, 1998) and, therefore, "designing for environment principles" (Suh, 1990) and the "green design approach" (Zuburtikudis, 2001) has been developed in the last decades. Further, Eco-innovation, which considers any innovation which reduces damage to the environment (Kanerva et al., 2009), has been increasing academic and industry interest because it is necessary to guarantee the profitability of companies (Porter and van der Linde, 1995; Pujari, 2006; Orsato and Wells, 2007; Ambec and Lanoie, 2008).

This paper examines which are the driving forces that determine the environmental orientation of the automotive firms while innovating.

In our previous study we confirmed that Process Orientation has a positive effect on the environmental orientation of the automotive firms while innovating. We defined Process oriented companies as those companies oriented to cost reduction and to the increase of capacity and flexibility, which previously has been determined as important factors to innovation adoption in organizations (Albors and Hervás, 2011).

Further, automotive customers are putting under pressure the automotive industry to become greener. Several authors have determined this as an opportunity to improve competitiveness and differentiation (Vastag et al., 1996, Enz and Siguaw, 1999, Ferrari et al., 2010). Then, the green market is increasing rapidly and the industry cannot ignore it. Product oriented companies are those companies that are focusing on increasing the quality or the number of products, to penetrate in new markets or to increase market share, and we have confirmed this companies to be more environmentally oriented, as they will try to reach green customers.

In the automotive market, regulations have been pushing the industry to improve the environmental impact of their products, specially in Europe. Moreover, the market, that is suppliers, customers and competitors, is more sensible to the market demands to reduce water, energy and waste consumption and to increase operational efficiency (Process orientation) and to the demand of new and innovative products (Product orientation). We confirmed that automotive firms that rely more on the market information sources that is, the information from customers, suppliers, competitors and external consultants, are more likely to be environmentally oriented, because they will be more process and product orientated.

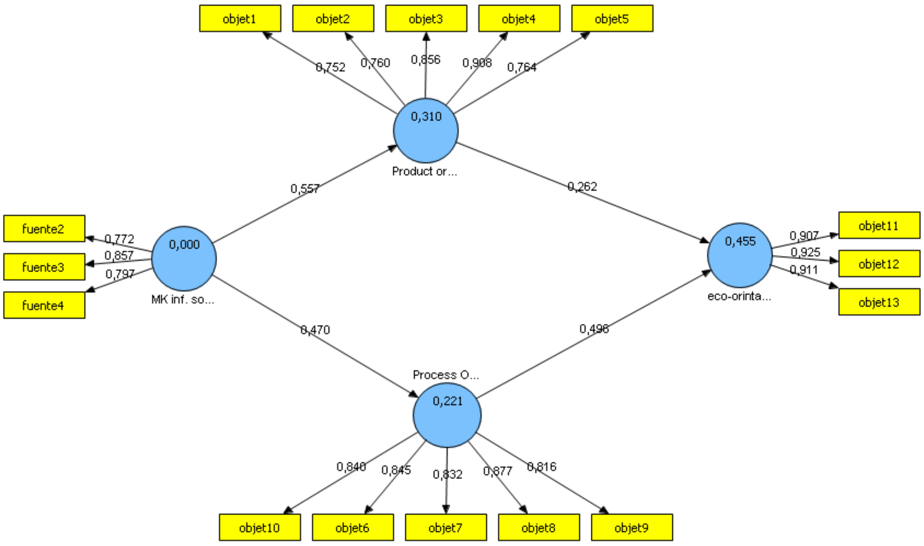
In this paper, we go one step further to identifying different patterns in which companies are approaching environmental orientation while innovating.

2. Materials and method.

We used the Spanish Technological Innovation Panel (PITEC) for the year 2010 to retrieve data for this study. Pitec database is a statistical instrument for studying the innovation activities of Spanish firms elaborated by the Spanish National Statistics Institute (INE). Following our previous study we chose a set of 224 firms from the automotive industry taking into account the variable ACTIN which makes a 44-industry breakdown replacing the original NACE codes.

Variable selection and the original model were justified the previous work. The purpose of that study was to identify some of the driving forces behind the environmental orientation of the automotive companies. Specifically, we tested the importance of the market information sourcess (coming from suppliers, clients, competitors and external consultants) to effectively orientate product and process improvements as the key factors in determining the environmental orientation of the automotive industry firms (figure 1)

Figure 1. Structural Model



The measurement model was confirmed with sufficient reliability and validity for all of the constructs in the research model using partial least square (PLS) method with SmartPLS 2.0.M3 (Ringle et al., 2005) software. We assessed reliability and validity of the research instrument (see table 1) using item reliability, internal consistency, and discriminant validity (Chin, 1998). First, we checked individual item loadings to evaluate individual item reliability (Chin, 1998). Secondly, we evaluated Cronbach's alpha to test internal consistency for each construct (Nunnally, 1978). Thirdly, we verified average variance extracted (AVE) to test convergent validity (Fornell and Larcker, 1981). Finally, we look at the square root of AVE (Hulland, 1999) to assess discriminant validity (see table 2). Results exceeded the thresholds suggested by leading staticians, indicating that the survey instrument was sufficient for measuring each construct and individually and that the structural model was assessed with confidence.

Further, we demonstrated that all of the path coefficients were statistically significant (see table 4) and that the model was predicted with relevance.

The results showed that eco-innovation activities are positively related to innovation (Segarra-Oña et al., 2011b), that is, the more focused companies are on processes and products when innovating the more environmentally oriented they are. More specifically, looking for operational flexibility, to increase production capacity, to reduce labor costs per unit or to reduce energy consumption per unit in the innovative process it's enhancing the environmental orientation too. Similarly, firms focused on new products, on increasing or substituting product range, on increasing product quality or on reaching greater market share or new markets, are also more likely to be environmentally orientated.

Finally, the model the model evidenced that organizations that rely importantly on market information sources to innovate are more likely to focus on process and product innovation and, therefore, are more likely to be environmentally oriented, as suggested Mondéjar-Jiménez et al (2010).

Although we have recognized some determinants that drive environmental orientation of the automotive industry when innovating, we can expect different patterns in how this determinants influence the environmental orientation. Several researchers have attempted to classify firms according to environmental attitudes and orientation (Abbaspour et al., 2006, Ferrari et al., 2010, Burciu et al. 2010, Segarra-Oña et al., 2011a). Therefore, we cannot assume that all the firms are single homogeneous population is often unrealistic. The aim of this work is to identify groups of companies within the automotive industry with different mechanisms driving their environmental proactivity. We used the FIMIX-PLS algorithm (Hahn et al., 2002), that combines a finite mixture procedure with an EM-algorithm (Jedidi et al., 1997) to identify groups of firms with similar behavior. This will allow us to identify different firms segments or groups with their characteristic estimates for relationships of latent variables in the structural model.

The first issue we face is selecting the appropriate number of segments. It is usual to repeat the FIMIX-PLS procedure with consecutive numbers of latent classes, that are compared attending to Akaike Information Criterion (AIC), the Controlled AIC (CAIC), the Bayesian Information Criterion (BIC) or the normed entropy statistic (EN). Following Ramaswamy et al. (1993), the first and the last criteria are critical for analyzing segment specific results.

Table 1 compares the class-specific computations for heuristic evaluation criteria.

Table 1. Criteria for model choice.

	K=2	K=3	K=4	K=5
AIC	1732.4	1620.0	1736.5	1817.2
BIC	1783.5	1698.4	1842.2	1950.1
CAIC	1783.6	1698.5	1842.3	1950.3
EN	0.481	0.807	0.665	0.605

EN values were the highest and AIC values where the lowest for the 3 segment case, which indicates the appropriateness of this classification. Moreover, we checked the % of firms assigned with a high probability (see table 2). As illustrated, 65.5 % of all the firms are well assigned with a probability of higher than 0.9 for the 3 segments case. These probabilities decline for higher numbers of segments, which indicates an increased fuzziness of segmentation. Therefore, three-group segmentation is demonstrated to be the most appropriate.

Table 2. Overview of the highest probability of assignment to a certain segment.

P_{ik}	K=2	K=3	K=4	K=5
0.9-1.0	0.422	0.655	0.327	0.291
0.8-0.9	0.166	0.157	0.197	0.139
0.7-0.8	0.157	0.085	0.175	0.135
0.6-0.7	0.175	0.058	0.135	0.148
0.5-0.6	0.081	0.045	0.117	0.126
0.4-0.5	0.000	0.000	0.040	0.112
SUM	1.000	1.000	0.991	0.951

Once we have determine the appropriate number of segments, we estimated the model and the precision of the PLS estimates for each segment (see table 3). The composite reliability indices are near or greater than 0.85 in all cases, and the convergent validity (*AVE*) values are near or greater than 0.5. The R^2 coefficients associated with latent variable regressions acceptable in most of the cases.

Table 3. Reliability measurements for the general model and for the three segments.

	General			Segment 1 81.2%			Segment 2 9.4%			Segment 3 9.4%		
	AVE	CR	R^2	AVE	CR	R^2	AVE	CR	R^2	AVE	CR	R^2
MK inf. sources	0.646	0.844		0.609	0.823		0.929	0.975		0.646	0.844	
Process Orientation	0.683	0.913	0.607	0.677	0.913	0.090	0.815	0.956	0.987	0.683	0.913	0.607
Product orientation	0.726	0.929	0.096	0.580	0.872	0.302	0.863	0.969	0.988	0.726	0.929	0.096
eco-orientation	0.742	0.896	0.880	0.834	0.938	0.587	0.887	0.959	0.990	0.742	0.896	0.880

CR: Composite Reliability

To evaluate each segment, we used cross validated PLS goodness of fit (GoF) measure (Tenenhaus et al.). GoF is calculated as the square root of the product of the geometric mean of the average communality (outer model) and the average R^2 (inner model). Table 4 shows model adjustments for each one of the three segments using bootstrapping procedure. An analysis of direct effects, highlights the dependence existing between the latent variables and allows to determine the differences between the groups.

Table 4. Disaggregate results for direct effects between latent variables.

	Global	Segment 1	Segment 2	Segment 3
MK inf. sources -> Process Orientation	0.47 (4.945)***	0.299 (2.884)**	0.994 (1972.043)***	0.779 (17.632)***
MK inf. sources -> Product orientation	0.557 (7.2)***	0.55 (7.995)***	0.994 (1392.468)***	-0.31 (3.969)***
Process Orientation -> eco-orientation	0.496 (5.211)***	0.459 (5.628)***	0.249 (3.859)***	-0.038 (1.097)
Product orientation -> eco-orientation	0.262 (2.493)**	0.438 (5.353)***	0.749 (11.66)***	-0.938 (118.798)***
GoF	0.483	0.467	0.929	0.607

* Significant values at the 5% significance level.
** Significant values at the 1% significance level.
***Significant values at the 0.1% significance level.

3. Results and discussions

To characterize the three uncovered firms segments, we conducted focused first in the model results.

The first segment (81.2%) is composed by firms which eco-orientation is positively and equally affected by Process Orientation (β= 0.459, $p<0.001$) and Product orientation (β= 0.432, $p<0.001$). That is, these companies eco-orientation is determined equally by the search for more operational flexibility, the increase on production capacity, the reduction of labor costs or energy consumption per unit, and the search for new or substituting products, the increase of product quality or the increase of market share or new markets. Further, information from suppliers, clients and competitors affect process and product orientation of these firms significantly and at the similarly when innovating. We call this group eco-balanced. Suppliers, competitors and clients pressure forces this companies to improve internally, through process improvements, and externally, through product improvements, which is leading these companies to think “eco” balancing the benefits of cost reduction and the access to new market niches.

The second segment (9.4%) model present outstanding results. AVE and Composite reliability are very high, R^2 results for every construct are over 0.98 and GoF is 0.929. This group is characterized by a higher market approach to environmental innovation (β= 0.749, $p<0.001$ for Product orientation vs. β= 0.249, $p<0.001$ for Process orientation). Then firms in this group will be highly environmentally oriented when innovating if they innovation activity is focused on new products, on increasing or substituting product range, on increasing product quality or on reaching greater market share or new markets. We call this group eco-marketers.

Finally, the third segment (9.4%) model presented some contradictions with the general model that should be highlighted. First, β coefficients are negative for 3 of the four relations, indicating that the influence is acting opposite to what we expected. Moreover, the negative relation between product orientation and eco-orientation is significant, that is, in this companies the higher the orientation to new product or new markets, the lower the orientation to environmental aspects when innovating. Therefore, we call this group eco-blind firms.

We have identified that these Process and Product orientation and the importance of market information sources are characteristics are acting in a different way in some firms compared to others. Actually, we detected 3 different patters of how environmental orientation is been influenced by this elements.

4. Conclusions

The purpose of this study is to identify groups of companies within the automotive industry with different mechanisms driving their environmental proactivity. Thus, this approach clarifies different approaches that act encouraging firms' environmental orientation.

We found 3 groups of companies which environmental orientation while innovation is driven differently. The biggest group of companies orientate towards environment balancing the internal orientation to improve processes and reduce environmental and cost impact and searching for new market products and niches to tap on the new green demand, eco-balanced.

In another group of companies, market orientation is pushing harder than processes to orientate companies' environmental innovation activity. This group is also highly influenced in the innovation process by the market information sources, namely, suppliers, competitors and clients. We called them eco-marketers.

Finally, the last group is opposing the general tendency in those relations, so this group innovative activity towards the market is acting negatively in the environmental orientation of the firms when innovating. It seem, that this group is not able or don't want to see the general path to approach environmental aspects in the innovation process. We called them eco-blind.

Generally speaking, innovation activities seeking energy savings, material savings or improving products and market position are affecting positively to the environmental orientation of the firms in the innovation activity.

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CAPÍTULO 6

CONCLUSIONES

1. Conclusiones.

En el primer trabajo de esta tesis centramos el estudio en el diseño sostenible en la industria manufacturera y en las necesidades que tienen las empresas al considerar la mejora de su comportamiento medioambiental a través del mismo. Los beneficios de la actitud proactiva hacia el eco-diseño y su ejecución han sido claramente identificados en la revisión de la literatura. Entre éstos se encuentran las mejoras de competitividad, la reducción de costes, una mejor imagen de la empresa o el desarrollo de nuevos productos. Sin embargo, varios investigadores han señalado que la industria necesita herramientas de apoyo para la consecución de los objetivos de eco-diseño.

El eco-diseño, que es un campo emergente tanto en investigación como en su aplicación práctica, tiene como objetivo ayudar a las organizaciones a obtener unos mejores resultados. Sin embargo, las decisiones de las administraciones públicas van, por lo general, por detrás de las acciones de muchas empresas y, en muchos casos, sus actuaciones no se están focalizando en los aspectos clave que permitan una orientación medioambiental mayor en el diseño de los productos.

Esta tesis, tras la evaluación inicial del estado del arte en materia de eco-diseño, se centra en directamente en el enfoque que está tomando la industria del automóvil a este respecto. En el segundo trabajo hemos puesto de relieve una amplia gama de acciones que un líder del sector de componentes del automóvil como Faurecia, ha tomado en los últimos años para garantizar el eco-diseño en el seno de su organización.

Reflejamos la información recogida en entrevistas con los expertos en eco-diseñodel grupo Faurecia, para detectar los objetivos medioambientales seguidos durante el proceso de innovación, focalizando nuestra atención principalmente en la fase de diseño.

Los resultados observados se ven reforzados por los resultados empíricos realizados en el mismo estudio sobre una muestra de empresas del sector. Específicamente, mostramos que la orientación medioambiental se ve influida por las características de la empresa. Mas específicamente, podemos decir que en las empresas de la industria de automoción en España, la proactividad medioambiental al innovar está determinada principalmente por el tamaño de las empresas (medido por el total de los ingresos), la inversión total, el tamaño de I+D (medido como el número de empleados en actividades de I+D), también, pero en menor medida, por la actividad formal de I+D (número de patentes) y por la orientación a la exportación.

En consecuencia con los resultados, las empresas más grandes, con un mayor número de patentes y con una amplia presencia internacional, son más propensas a estar medioambientalmente orientadas cuando están innovando. Como las innovaciones de las empresas del sector del automóvil se concentran y tienen lugar principalmente en la fase de diseño de productos, podemos concluir que el eco-diseño es más probable que ocurra en las grandes empresas con alta orientación hacia el exterior y hacia la innovación y que estas empresas son las que están conduciendo la eco-innovación en toda la industria del automóvil.

Además, en este mismo estudio determinamos la inexistencia de diferencias significativas en las características de las empresas previamente citadas atendiendo a otros aspectos como la reducción del consumo de energía y de materiales o el cumplimiento de la legislación ambiental. A pesar de que la reducción de energía y de materiales pueden estar relacionados con la innovación medioambiental, como se demuestra en estudios previos citados de esta tesis, también están muy influenciados por otros elementos de caracter operativo, por lo que la orientación de la compañía podría verse afectada por otras variables como el rendimiento económico, la estructura de costes o su situación financiera.

Tras evaluar aspectos relacionados con la estructura de la empresa, centramos nuestros esfuerzos en establecer aquellas características de comportamiento empresarial que impulsan la orientación medioambiental de la empresa en el proceso innovador. El propósito del siguiente trabajo fue identificar algunas de las fuerzas impulsoras que están detrás de la orientación ambiental de las empresas del sector del automóvil. En concreto, en la investigación se propone validar las hipótesis relacionadas con la importancia de las fuentes de información del mercado (información procedente de proveedores, clientes, y competidores) para orientar eficazmente la mejora de productos y procesos que, a su vez, se consideran como los factores clave en la determinación de la orientación ambiental de las empresas de la industria del automóvil. Planteamos un modelo de ecuaciones estructurales mediante mínimos parciales cuadrados (PLS) para explicar las relaciones entre estos constructos. La evaluación confirmó con la suficiente fiabilidad y validez todos los constructos del modelo planteado. Además, demostramos el cumplimiento de todas las relaciones propuesta en el modelo estructural y la significancia estadística de las mismas.

Estos resultados son consistentes con investigaciones anteriores (Segarra-Oña *et al*., 2011b) donde las actividades de eco-innovación se relacionan positivamente con las actividades de innovación. Las empresas que se encuentran orientadas hacia procesos y productos en el proceso de innovación tienden a estar más medioambientalmente orientadas la hora de innovar. La consistencia en los hallazgos sugiere que las empresas que buscan una mayor flexibilidad operacional, aumentar la capacidad de producción, reducir los costes laborales por unidad o reducir el consumo de energía por unidad cuando están buscando nuevas innovaciones, también están más dispuestas a adoptar una orientación medioambiental.

Por otra parte, las empresas que se centran en desarrollar nuevos productos, en el aumento o la sustitución de gama de productos, en el aumento de la calidad del producto o en alcanzar una mayor cuota de mercado o nuevos mercados, son también más propensas a estar medioambientalmente orientadas.

Por último dentro de este estudio, hemos establecido la importancia de la dependencia de la innovación de las empresas de la información proveniente de su entorno (proveedores, clientes y competidores) a la hora de orientar la actividad innovadora tanto hacia los procesos como hacia los productos. Estos resultados sugieren que las organizaciones que dependen de manera importante de las fuentes de información del mercado para innovar son más propensas a centrarse en la innovación de productos y procesos y, por lo tanto, tienen más probabilidades de orientarse hacie el medioambiente. Estos hallazgos también son apoyados por Mondéjar-Jiménez et al (2010) quienes reportaron que, cuanto mayor es la influencia de los interesados en las decisiones ambientales, mayor será la orientación medioambiental de la empresa.

En definitiva, este estudio aclara los aspectos más importantes a considerar para fomentar la orientación de las empresas hacia el medioambiente durante el proceso de innovación. Parece que la promoción de la innovación sin duda dará lugar a la promoción de la orientación medioambiental. Las actividades de innovación que buscan el ahorro de energía, ahorro de materiales o productos mejorados están descubriendo nuevas directrices para que en la empresa se produzca el cambio de innovación a eco-innovación. Podremos decir pues, que los aspectos ambientales están permeando en la cultura de las empresas cambiando la orientación del proceso de innovación hacia posiciones y actitudes que garanticen la protección del medioambiente. Teniendo en cuenta que la primera y mayor innovación en el sector se produce en la etapa de diseño del automóvil, cabe esperar que la orientación medioambiental esté presente desde la misma concepción del producto. En consecuencia, si queremos para alentar una deriva medioambiental del diseño se pueden fomentar otros aspectos como el ahorro de energía, ahorro en materiales, creación de nuevos productos o mercado (búsqueda del nicho "verde"), entre otros.

Para finalizar la caracterización realizada, completamos el estudio anterior con un estudio más pormenorizado de modelo realizado. Como podemos esperar, no todas las empresas del sector del automóvil se rigen por los mismos mecanismos en las relaciones detectadas en el anterior estudio. Podemos esperar que en algunas empresas la relación entre los distintos constructos identificados sean más fuertes que en otras, o que en algunas estas relaciones sean significativas y en otras no. Por ello, pretendemos diferenciar las empresas según las distintas formas en las que estas relaciones se manifiestan. Mediante el estudio realizado mediante la técnica FIMIX-PLS, hemos identificado 3 grupos de empresas distintos atendiendo a las relaciones entre los distintos constructos. Hemos determinado que en la mayoría (80,21%) de las empresas la orientación medioambiental viene afectada de manera similar por la orientación a productos y a procesos, por lo que hemos llamado a este grupo de empresas, eco-equilibrados.

Por otra parte, encontramos dos grupos cuyos mecanismos son sustancialmente distintos y cuyo tamaño es similar (sobre 9% cada uno). En el primero de ellos, la orientación ecoinnovadora viene determinada de forma significativa únicamente por la orientación al producto en el proceso de innovación. Es decir, que sólo la búsqueda de nuevos productos o mercados hace que las empresas puedan orientarse medioambientalmente. El objetivo pues de estas empresas es cubrir nichos "verdes" que se están creando en el mercado, por lo que les llamamos eco-marketinianos.

En estos dos grupos se confirma la influencia de las fuentes de información provenientes del mercado en la orientación a productos y procesos, tal y como se demostró para el modelo general en el anterior trabajo.

Finalmente, identificamos un grupo de empresas donde las relaciones de la orientación hacia la innovación de productos y procesos impactan de forma negativa en la orientación medioambiental. Podemos decir que estas empresas no ven los beneficios que la orientación medioambiental puede reportarles y, consecuentemente los llamamos eco-ciegos.

Así pues, en esta tesis no sólo hemos identificado aquellas características de las empresas que pueden influir en la orientación de las empresas hacia el eco-diseño sino que hemos establecido los mecanismos por los cuales las empresas del sector del automóvil van a incrementar su orientación mediambiental en ele proceso de innovación y, consecuentemente, en el proceso de diseño. Más aún, hemos identificado tres mecanismos distintos mediante los cuales podemos influir en la orientación medioambiental en el proceso de innovación dentro del sector del automóvil. La correcta clasificación del comportamiento de las empresas en cada uno de estos grupos permitiría dirigir mejor los esfuerzos realizados parar lograr una mayor orientación hacia el medioambiente en la fase de diseño.

2. Limitaciones.

Las limitaciones de este estudio son, básicamente debidas a las restricciones de la base de datos utilizada y nos sugieren ideas para extender y mejorar el análisis realizado.

Por una parte, resulta necesario estudiar de manera cualitativa, a través de un estudio de casos, la casuística concreta en cada uno de los grupos de empresas identificados atendiendo a los mecanismos que influyen en la orientación medioambiental cuando se innova.

Además, en el estudio realizado del sector del automóvil se encuentra limitado por el tamaño de la muestra. Aunque la selección de las empresas viene avalada por el INE, resulta algo escasa para generalizar los resultados obtenidos, por lo que debería ampliarse, bien con muestras de otros países de nuestro entorno, bien volviendo a realizar el análisis aumentado el número de empresas en la muestra con datos de años posteriores.

Por ultimo, hay que remarcar que las conclusiones deben considerarse teniendo en cuenta que es probable la existencia factores moderadores pueden influir de distinta forma en las empresas del sector.

3. Futuras líneas de investigación.

Como acciones futuras nos proponemos analizar en mayor profundidad los factores que dificultan o facilitan la innovación y el diseño medioambiental a nivel interno y externo de la empresa, así como la influencia de las medidas legislativas como la Directiva IPPC o la Directiva sobre comercio de emisiones. Por lo tanto, será necesario llevar a cabo estudios cualitativos más detallados, así como implementar el estudio a otros países en el sector donde automóvil tiene una preponderancia similar (por ejemplo, Francia o Alemania) y comparar los resultados.

Se considera relevante la necesidad de realizar una investigación futura que pueda enriquecer el análisis realizado en los artículos mediante en el uso de diferentes metodologías. En primer lugar, un estudio en profundidad de tipo cualitativo será necesario para obtener más información sobre los resultados obtenidos en los diferentes grupos o segmentos estudiados.

Para validar los resultados obtenidos se pretende, por una parte, incrementar la muestra con más empresas del sector.

Por otra parte, se pretende realizar un análisis de panel, analizando a través del tiempo el comportamiento de las distintas empresas para determinar la evolución de los indicadores estudiados.

En definitiva, el eco-diseño y la orientación medioambiental aparecen como un campo académico apasionante y todavía por explorar. Las posibles futuras líneas de investigación son numerosas y altamente interesantes. La presente tesis doctoral, además de contribuir en aspectos claves para el conocimiento y comprensión de la eco-diseño y la orientación medioambiental cuando se innova, espera abrir nuevas puertas a futuras investigaciones que ayuden a desarrollar y promover este importante campo de estudio.

ANEXOS