



TESE DE DOUTORAMENTO

ASSESSING DRIVERS'
PREFERENCES FOR HYBRID
VEHICLES VIA DISCRETE CHOICE
EXPERIMENTS

Djamel Rahmani

DEPARTAMENTO DE FUNDAMENTOS DA ANÁLISE
ECONÓMICA
PROGRAMA DE DOUTORAMENTO EN ANÁLISE ECONÓMICA
E ESTRATEXIA EMPRESARIAL
FACULTADE DE C. ECONÓMICAS E EMPRESARIAIS

SANTIAGO DE COMPOSTELA

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2017



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“Assessing drivers’ preferences for hybrid vehicles via discrete choice experiments”

Presentada por D. Djamel Rahmani

Alumno do Programa de Doutoramento en Análise Económica e Estratexia Empresarial

Autoriza a presentación da tese indicada, considerando que reúne os requisitos esixidos no artigo 34 do regulamento de Estudos de Doutoramento, e que como Directora da mesma non incurre nas causas de abstención establecidas na lei 40/2015.

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Assessing drivers' preferences for hybrid vehicles via discrete choice experiments

SUMMARY

Road transport is by far the biggest emitter of green-house gases (GHG) from transport sector (European Commission, 2014). Despite the fact that the European Union is implementing several policies and incentives aiming to promote the use of alternative fuel vehicles (AFVs), their market share still remains very small. Thus, it would be very interesting to analyze why drivers are not tempted by AFVs in order to improve the existing AFV programs and initiatives. Stern (2007) suggested that energy and climate policy success involves not only producing low-carbon technology (technology policy) and making unattractive fossil fuels (carbon pricing policy), but also improving energy decisions and behaviors of drivers (behavioral change policy). Therefore, the objective of this dissertation is to analyze the relevant factors that drive people's vehicle choice decisions, especially those that are key to prefer hybrid electric vehicles (HEVs) over conventional vehicles. A special interest is given to the effects of incentives, tastes variations at several levels, reference point and vehicle size on vehicle choice decisions. To achieve these purposes an online discrete choice experiment (DCE) is administered to 1,016 Spanish drivers. A total of four different Chapters are presented to improve the understanding of 1) drivers' preferences and willingness-to-pay (WTP) for HEVs; 2) variations in tastes for vehicle attributes and alternatives among four distinct driver groups; 3) variations in driver tastes for vehicle type and attributes according to vehicle size; 4) and the effect of the reference point (or context of choice) on vehicle choice decisions and the consequences of ignoring such reference point in the context of DCEs. The present dissertation led to important and innovative conclusions and some future research ideas that are presented in the concluding section.

KEYWORDS: Hybrid electric vehicles (HEV), alternative fuel vehicles (AFV), preference heterogeneities, reference point effect, discrete choice experiment (DCE), random parameter logit model (RPL), road transport, global warming, climate change.



Estimación das preferencias dos condutores dos vehículos híbridos a través de experimentos de elección discreta

RESUMO

O transporte por estrada é o meirande emisor de gases de efecto invernadoiro (GEI) dentro do sector do transporte (Comisión Europea, 2014). A pesar de que a Unión Europea está aplicando varias políticas e incentivos para promover o uso de vehículos de combustibles alternativos (VCAs), a súa cota de mercado segue a ser moi baixa. Polo tanto, parece interesante analizar por que os condutores se resisten aos VCAs para poder mellorar as políticas e incentivos existentes. Stern (2007) suxeriu que o éxito das políticas enerxéticas e climáticas non consiste só en desenvolver tecnoloxías de baixas emisións de carbono (política tecnolóxica), ou en facer pouco atractivos os combustibles fósiles (políticas de fixación do prezo do carbono), senón tamén en mellorar as decisións e comportamentos enerxéticos dos condutores (políticas para acadar cambios de comportamento). Polo tanto, o obxectivo desta tese doutoral é analizar os factores relevantes que impulsan as decisións de compra de vehículos, especialmente aquelas que son claves para preferir os vehículos híbridos non enchufables (VHNE) con respecto aos vehículos convencionais. Nesta investigación dáse unha énfase especial aos efectos dos incentivos, ás variacións dos gustos, ao punto de referencia ou ás circunstancias baixo as cales se escolle, e ao tamaño do vehículo nas decisións de compra de vehículos. Para acadar estes propósitos adminístrase un experimento de elección discreta (EED) en liña a 1,016 condutores españois. Preséntanse un total de catro capítulos diferentes para mellorar a comprensión de: 1) as preferencias dos condutores e as súas disposicións a pagar (DAP) por VHNEs; 2) as variacións nos gustos polos atributos dun vehículo entre distintos tipos de condutores; 3) as dispersións nos gustos dos condutores polo tipo de vehículo e os atributos segundo tamaño do vehículo; 4) e o efecto do punto de referencia nas decisións de compra de vehículos e as consecuencias de ignoralo no contexto dos EEDs. A presente tese conduce a conclusións relevantes e innovadoras, e promove algunhas ideas de investigación futura que se presentan na sección de conclusións.

PALABRAS CLAVES: Vehículos híbridos non enchufables (VHNEs), vehículos de combustible alternativo (VCAs), preferencias heteroxéneas, punto de referencia, experimento de elección discreta (EED), modelo *logit* con parámetros aleatorios (LPA), transporte por estrada, quentamento global, cambio climático.



Estimación de las preferencias de los conductores por los vehículos híbridos a través de experimentos de elección discreta

RESUMEN

El transporte por carretera es el mayor emisor de gases de efecto invernadero (GEI) del sector de transporte (Comisión Europea, 2014). A pesar de que la Unión Europea está aplicando varias políticas e incentivos para promover el uso de vehículos de combustibles alternativos (VCAs), su cuota de mercado sigue siendo muy baja. Por lo tanto, sería muy interesante analizar por qué los conductores se resisten a los VCAs con el fin de mejorar las políticas e incentivos existentes. Stern (2007) indicó que el éxito de las políticas energéticas y climáticas no consiste sólo en desarrollar tecnologías de bajas emisiones de carbono (política tecnológica), o hacer poco atractivos a los combustibles fósiles (políticas de fijación del precio del carbono), sino también en mejorar las decisiones y comportamientos energéticos de los conductores (políticas para lograr cambios de comportamiento). Por lo tanto, el objetivo de esta tesis doctoral es analizar los factores relevantes que impulsan las decisiones de compra de vehículos, especialmente aquellos que son claves para preferir a los vehículos híbridos no enchufables (VHNEs) a los vehículos convencionales. En esta investigación se da un especial interés a los efectos de los incentivos, las variaciones de los gustos a varios niveles, el punto de referencia o circunstancias bajo las cuales se hace la compra y el tamaño del vehículo en la compra de vehículos. Para lograr estos propósitos se administra un experimento de elección discreta (EED) online a 1,016 conductores españoles. Se presentan un total de cuatro Capítulos diferentes para mejorar la comprensión de 1) las preferencias de los conductores y sus disposiciones a pagar (DAP) por VHNEs; 2) variaciones en los gustos por los atributos entre grupos diferentes de conductores; 3) dispersiones en los gustos de los conductores por el tipo de vehículo y los atributos según el tamaño del vehículo; 4) y el efecto del punto de referencia en las decisiones de compra de vehículos y las consecuencias de ignorarlo en el contexto de los EEDs. La presente tesis condujo a conclusiones relevantes e innovadoras y a algunas ideas de investigación futura que se presentan en la sección de conclusiones.

PALABRAS CLAVES: Vehículos híbridos no enchufables (VHNEs), vehículos de combustible alternativo (VCAs), preferencias heterogéneas, punto de referencia, experimento de elección discreta (EED), modelo *logit* con parámetros aleatorios (LPA), transporte por carretera, calentamiento global, cambio climático.



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RESUMEN





RESUMEN

INTRODUCCIÓN

En la última Conferencia de las Naciones Unidas sobre el Cambio Climático (COP 21) que se celebró en París, 195 países se comprometieron a limitar el aumento de la temperatura media global por debajo de los 2°C con respecto a los niveles preindustriales. Especialmente, la Unión Europea (UE) expresó su intención para reducir las emisiones de gases de efecto invernadero en al menos un 40% en 2030 con respecto a los niveles de 1990, así como los objetivos de eficiencia energética y energías renovables de al menos el 27% (European Commission, 2016). En los últimos años, la UE ha lanzado varias medidas para abordar el problema del cambio climático y reducir la dependencia del petróleo extranjero, en particular del transporte por carretera. Por lo tanto, la mayor parte de las políticas energéticas y ambientales de la UE están dirigidas para lograr una alta eficiencia energética y un bajo impacto ambiental a través de la mejora de los motores de combustión interna, y la promoción del uso de vehículos de combustible alternativo (VCAs), tales como vehículos que utilizan biocombustibles (VBs), vehículos eléctricos (VEs), vehículos híbridos no enchufables (VHNEs) y vehículos híbridos enchufables (VHEs), entre otros. Sin embargo, pese al hecho de que la presencia de estas tecnologías en el sector de la automoción ha aumentado considerablemente en los últimos años, la reticencia de los conductores hacia los VCAs sigue siendo muy alta. Stern (2007) sugirió que el éxito de la política energética y climática implica no sólo producir tecnología de baja emisión de carbono (política tecnológica) y hacer poco atractivos los combustibles fósiles (política de precios de carbono), pero también mejorar las decisiones energéticas y el comportamiento de los conductores (política de cambio de comportamiento). Por lo tanto, sería interesante identificar y comprender los factores determinantes implicados en las decisiones de elección de vehículos para cambiar los comportamientos de los conductores o para empujarlos hacia los VCAs; especialmente VHNEs que son el foco de la presente investigación. En particular, las preferencias del

conductor por atributos específicos de un vehículo, la estructura de las preferencias, las variaciones del gusto, el efecto del tamaño del vehículo, los efectos de los incentivos monetarios y no monetarios, y el efecto del punto de referencia en el proceso de toma de decisión de los conductores han recibido una atención especial en la presente tesis.

La mayor parte de la literatura existente (Beck et al., 2013; Chua et al., 2010; Heffner et al., 2007; Hess et al., 2012; Hoen and Koetse, 2014; Ito et al., 2013; Krupa et al., 2014; Link et al., 2012; Potoglou and Kanaroglou, 2007; Thatchenkery and Beresteanu, 2008; Ziegler, 2012) ha atribuido el aumento en la elección de los VCAs al rendimiento, potencia, ahorro en combustible, número de puertas o asientos, autonomía, disponibilidad de combustible, incentivos públicos (exenciones o reducciones de impuestos); mientras que un descenso de la demanda está relacionada con los precios, los costos de consumo de combustible, costos de mantenimiento, las emisiones y el tiempo de recarga. Resultados mixtos han sido encontrados con respecto a la elección entre diferentes tipos de vehículos. Mientras que algunos estudios (Hoen and Koetse, 2014; Link et al., 2012; Ziegler, 2012) mostraron que los vehículos convencionales son preferidos a los VCAs, otros (Hess et al., 2012; Ito et al., 2013) informaron que al menos algunos tipos de VCAs se prefieren a los vehículos convencionales. Por otra parte, se ha encontrado que las preferencias por los VHNEs están influidas positivamente por un alto ingreso, un mayor nivel de estudios, y la conciencia ambiental (Potoglou and Kanaroglou, 2007; Thatchenkery and Beresteanu, 2008), el kilometraje anual (Ziegler, 2012), diferentes significados simbólicos asociados con los VHNEs incluido el logro de cierta imagen social (Chua et al., 2010), y ser dueño de la última tecnología (Heffner et al., 2007); e influidas negativamente por la edad, y por ser un hombre (Link et al., 2012). Además, Axsen et al. (2009) demostraron el papel de los efectos vecinos sobre la demanda de VHNEs, afirmando que una penetración superior de los VHNEs dio lugar a una mayor demanda y disposición a pagar por los VHNEs. La mayor parte de la literatura citada anteriormente se llevó a cabo en América del Norte (Axsen et al., 2009; Heffner et al., 2007; Potoglou and Kanaroglou, 2007; Thatchenkery and Beresteanu, 2008), donde los VHNEs son mucho más populares que en Europa. En España, entre los 1,147,007 turismos vendidos en 2016, sólo el 2.70% eran vehículos híbridos (VHNEs y VHEs) (ANFAC, 2017). Además, Choo y Mokhtarian (2004) informaron de que los propietarios de vehículos de diferentes tamaños tienen diferentes preferencias y actitudes. Por lo tanto, las variaciones de gusto por

los tipos de vehículos y atributos de acuerdo al tamaño del vehículo deberían ser analizadas.

Todavía hay muchas incógnitas sobre el proceso de toma de decisiones. La mayor parte de las teorías económicas tradicionales (Becker, 1976) consideran que la gente se comporta racionalmente (maximizan su utilidad), mientras que enfoques conductuales más recientes (Samuelson y Zeckhauser, 1988; Tversky y Kahneman, 1981) mostraron que las decisiones de elección pueden también estar sujetas a factores cognitivos irracionales tales como el statu quo, el punto de referencia o, simplemente la aversión a la pérdida, mediante el uso de modelos más flexibles de elección discreta. La teoría prospectiva de Kahneman y Tversky (1979) extendida a la teoría de la perspectiva acumulativa (Tversky y Kahneman, 1992) fue desarrollada para explicar este conflicto. La teoría estipula que los individuos evalúan los bienes comparando sus ganancias y pérdidas relativamente a un punto de referencia, y que las pérdidas se valoran más que las ganancias correspondientes, denotando dicho comportamiento como la aversión a la pérdida. La dependencia del punto de referencia es el principal pilar de la teoría de la perspectiva porque las utilidades se definen alrededor del punto de referencia. Por lo tanto, es vital identificar y tener en cuenta el punto de referencia apropiado que los individuos consideran al hacer una elección. Los conceptos anteriores han sido probados y apoyados en la elección de viajes (De Borger y Fosgerau, 2008, Hess et al., 2008; Hjørth y Fosgerau, 2009), pero rara vez en la elección de vehículos y aún menos en el contexto de los experimentos de elección discreta (EED), donde a menudo se incluye una opción de referencia (statu quo) para hacer las situaciones de elección más realistas. La elección de la opción de statu quo puede reflejar la preferencia por la situación actual (Lanz y Provins, 2012), o simplemente evitar elecciones complejas (alternativas similares) para reducir los esfuerzos mentales y emocionales (Beshears et al., 2008), evitando un posible arrepentimiento (Samuelson y Zeckhauser, 1988), protestando (Meyerhoff y Liebe, 2009), mientras continua buscando la mejor opción (Dhar, 1997). Muchas veces, la opción de no elegir (status quo) se sustituye por una opción constante definida como la situación actual, las metas (Heath et al., 1999), las aspiraciones (Hoffmann et al., 2013), las expectativas (Bartling et al., 2015; Banerji y Gupta, 2014), y adquisiciones en el pasado (Baker et al., 2012) entre otras, lo que conduce a diferentes estimaciones. Por lo tanto, sería importante proporcionar una mayor aclaración sobre este proceso para mejorar la comprensión y la predicción del comportamiento a través de los EEDs.

Además, los análisis de comportamiento de elección se llevan a cabo a menudo utilizando un modelo logit multinomial (MLM), que es un modelo muy restrictivo. Bajo la propiedad de independencia de alternativas irrelevantes (IAI), el MLM asume gustos fijos entre los encuestados, alternativas y a través del tiempo, lo que no siempre es una suposición realista. Las personas son diferentes y por lo tanto tendrían diferentes gustos. Además, en el contexto del EED, cada individuo se enfrenta a decisiones de elección múltiple, de modo que sus respuestas repetidas pueden estar correlacionadas en el tiempo (entre conjuntos de opciones) y entre atributos y alternativas (en un conjunto de opciones determinado). Captar la heterogeneidad asociada con los efectos observados y no observados es crucial para mejorar la comprensión de las preferencias de la gente. Por lo tanto, sería muy interesante analizar la heterogeneidad en las preferencias en varios niveles a través del uso de modelos de elección discreta más flexibles.

La presente tesis se justifica por la necesidad de una comprensión adicional de los factores racionales e irracionales implicados en las decisiones de elección de vehículos. El objetivo es mejorar las predicciones de las preferencias de los conductores y explicar mejor el papel de las políticas ambientales orientadas a aumentar el uso de VCAs, especialmente los VHNEs. La presente análisis se centra en los VHNEs porque además del hecho que esos coches no sufren las limitaciones debidas a las baterías se venden en España más que VHEs.

OBJETIVOS Y RESULTADOS PRINCIPALES

El principal objetivo de esta tesis es explorar los factores relevantes implicados en las decisiones de elección de vehículos, especialmente aquellos que son clave para preferir los VHNEs a los vehículos convencionales. Los VHNEs no son todavía populares en España; por lo tanto, no está claro el papel que tendrían en sustituir las tecnologías convencionales en un futuro próximo. En este contexto, las preferencias por VHNEs y sus atributos son evaluadas entre 1,016 conductores españoles. En particular, los gustos para el tipo de vehículo, el precio, el consumo de combustible, emisiones de CO₂ y la adaptación para funcionar con biocombustibles han sido evaluados usando experimentos de elección discreta (EEDs) llevados a cabo por internet. Esta investigación está organizada en cuatro capítulos empíricos que tienen diferentes objetivos y enfoques.

El primer Capítulo analiza la elección de vehículos de tamaño pequeño y mediano y tiene los siguientes objetivos específicos:

1. Probar si los individuos con preferencias fuertes hacia los incentivos basados en reducciones en el precio a través de subsidios, exención de impuestos (en los gastos de matrícula), parking gratuito, acceso a los carriles prioritarios e incentivos de reputación serían más propensos a elegir VHNEs. En demás palabras, ¿considerarían los individuos esos incentivos cuándo compran VHNEs?
2. Probar si diferentes individuos perciben de manera diferente los VHNEs y los atributos de un vehículo. Los estudios a menudo ignoran las heterogeneidades individuales cuándo evalúan las preferencias por los VCAs, un supuesto poco realista, ya que diferentes individuos pueden comportarse de diferentes maneras. Por lo tanto, será interesante abordar este tema utilizando análisis de elección discreta más flexible que permite que las preferencias sean heterogéneas entre los individuos de la muestra.
3. Evaluar la disposición a pagar (DAP) de los individuos por un VHNE, un vehículo con alta eficiencia energética y bajos impactos ambientales, y que esté adaptado para funcionar con biocombustibles. Varios estudios estimaron la DAP por los VCAs, pero a menudo no se derivan las distribuciones de la DAP. Incluso cuando se derivan las distribuciones de la DAP, a menudo se hace de una manera no muy adecuada o completamente inapropiada (véase Daly, et al., 2012). A veces el problema está en las distribuciones asumidas para los parámetros. En muchos estudios el parámetro monetario se mantiene fijo (ignorando sus dispersiones), mientras que en otras ocasiones se asumen distribuciones para ciertos atributos que permiten preferencias positivas y negativas para tales atributos, aunque quizás para una de estas dos direcciones estas expectativas no son razonables. Además, a veces el problema consiste en los métodos utilizados para estimar las DAPs. En particular, cuando el ratio de la DAP es una división de dos distribuciones, el uso del método Delta o Krinsky-Robb para construir las distribuciones de las DAPs puede ser inapropiado debido a que las distribuciones de las DAPs podrían no tener momentos finitos para ciertas combinaciones de distribuciones en el ratio de la DAP (Daly, et al., 2012). Por lo tanto, es interesante llevar a cabo un análisis donde se asume la distribución más apropiada para los parámetros asociados a los atributos y donde se aplica un método

de simulación que garantiza la existencia de momentos finitos para las distribuciones de la DAP.

En general, se ha encontrado que los conductores tienen conceptos erróneos sobre VHNEs. Los resultados muestran que los conductores que dan mayor importancia tanto al pase de estacionamiento gratis como a la imagen social tienen más probabilidad de seleccionar VHNEs, lo que implica que ofrecer espacio de estacionamiento gratis y promover la imagen verde asociada con los VHNEs pueden ayudar a los conductores a optar por los VHNEs. Del mismo modo, y de acuerdo con los hallazgos de estudios anteriores (Adler et al., 2003, Potoglou y Kanaroglou, 2007), los resultados revelan que las personas prefieren los vehículos con bajo precio, bajo consumo de combustible, bajas emisiones y vehículos aptos para funcionar con biocombustibles. Además, se ha encontrado una importante heterogeneidad en las preferencias por los atributos de un vehículo entre los conductores, mostrando que los incentivos públicos deben ser personalizados de acuerdo a las diferencias de gustos. Por otra parte, en condiciones de *ceteris paribus*, las personas tienen más probabilidad de pagar una prima por un vehículo con alta eficiencia energética y bajos impactos ambientales, y que esté adaptado para funcionar con biocombustibles, pero no por el hecho de ser un VHNE. Por lo tanto, las políticas actuales basadas en subsidios económicos aplicadas aisladamente para promover este tipo de vehículos pueden tener un efecto limitado en la extensión de su uso. Por eso, una mezcla de políticas de diversos incentivos (incluyendo campañas de información) puede ser necesaria.

El segundo Capítulo también se centra en la elección de vehículos pequeños y medianos y busca respuestas a los siguientes objetivos específicos:

1. Analizar la heterogeneidad en las preferencias por los tipos de vehículos y sus atributos entre diferentes grupos de conductores, previamente identificados mediante un modelo de clases latentes (MCL).
2. Identificar los grupos de conductores que son más conscientes de los problemas ambientales y aquellos que son más propensos a comprar VHNEs.
3. Conocer la disposición de cada grupo de conductores a hacer un esfuerzo económico para adoptar VHNEs.

Los resultados identifican 4 grupos (o clases) de individuos cuyas preferencias son diferentes entre sí. La heterogeneidad se manifestó por la importancia relativa dada a los diferentes atributos del vehículo, el número y el orden de los atributos que influyen sobre la elección de vehículos. En particular, los resultados demuestran que los VHNEs son significativamente preferidos por dos grupos de conductores, aunque uno de ellos prefiere los VHNEs en parte por incentivos de reputación; Mientras que los otros dos grupos no aprecian los VHNEs con respecto a los vehículos convencionales. Otros hallazgos pueden servir como una guía para diseñar estrategias precisas para promover tecnologías de transporte sostenibles y dirigirlas a la población objetiva adecuada.

El tercer Capítulo compara la forma en que los conductores se comportan cuando eligen entre vehículos pequeños/medianos y vehículos grandes. Este capítulo tiene los siguientes objetivos específicos:

1. Analizar las diferencias en las preferencias por los tipos de vehículos y sus atributos según el tamaño del vehículo. Específicamente, se comparan las preferencias de dos grupos de conductores: los futuros conductores de un modelo de vehículo de tamaño pequeño/mediano y aquellos que probablemente comprarán un modelo de vehículo grande. Estudios anteriores (Krupa et al., 2014) mostraron que el tamaño del vehículo influye en la elección del vehículo, pero nunca se examinó cómo los gustos por los atributos de un vehículo cambian según el tamaño del vehículo.
2. Verificar si los conductores de vehículos de tamaño grande son menos sensibles al medio ambiente que los conductores de vehículos de tamaño pequeño/mediano.
3. Verificar si las diferencias en las preferencias por atributos dan lugar a diferencias en la disposición a pagar (DAP) por los atributos. Por lo tanto, se da un interés especial a estas cuestiones en este capítulo.
4. Captar heterogeneidad adicional en las preferencias entre conductores, alternativas, atributos y en el tiempo. Estas fuentes adicionales de heterogeneidad son a menudo ignoradas en los estudios, pero son muy importantes para comprender mejor las preferencias de los conductores.

Los resultados proporcionan evidencia de las preferencias de los conductores por los vehículos pequeños/medianos sobre vehículos grandes y para los VHNEs sobre los vehículos

convencionales. Además, se ha encontrado que los conductores de vehículos grandes tienen un patrón de preferencias por los atributos ambientales idénticos a los de los conductores de vehículos pequeños/medianos. También se ha encontrado que las preferencias de los conductores de vehículos pequeños/medianos son más heterogéneas que las de los conductores de vehículos grandes. Asimismo, en condiciones de *ceteris paribus*, los conductores no están dispuestos a pagar una prima por los VHNEs en comparación con los vehículos convencionales, independientemente del tamaño del vehículo. Sin embargo, es probable que los conductores paguen una prima por un vehículo con bajo costo de consumo de combustible, bajas emisiones y que esté adaptado para funcionar con biocombustibles. Los resultados sugieren que los conductores no asocian reducciones en el consumo de combustible y las emisiones de CO₂ con los VHNEs. Por lo tanto, la promoción pública de estas mejoras puede aumentar la demanda de VHNEs.

El cuarto Capítulo aborda el papel del punto de referencia en un EED aplicado para evaluar las preferencias por los vehículos de tamaño pequeño/mediano. Los objetivos específicos de este capítulo son:

1. Comprobar el efecto del punto de referencia, a menudo ignorado al analizar las elecciones, en particular las hechas en el contexto de los EEDs.
2. Identificar el punto de referencia más preciso considerado por los conductores al comprar un vehículo nuevo; Especialmente en el contexto de un EED. En particular, se han probado tres puntos de referencia individuales diferentes.
3. Comprobar cómo las reducciones en el precio, el consumo de combustible e el impacto ambiental de los nuevos vehículos ofrecidos en el EED en comparación con los vehículos actuales de los conductores influyen en sus preferencias individuales.

En general, se ha demostrado que los modelos empíricos se ven afectados por los puntos de referencia, e ignorar tal efecto conduce a predicciones sesgadas. Además, los resultados muestran que las preferencias por los vehículos se forman alrededor del vehículo actual de los participantes (*statu quo*). Los resultados sugieren que no considerar correctamente la opción del *statu quo* puede sesgar nuestros resultados y reduce la capacidad de los EEDs para explicar las preferencias de los conductores. Estos hallazgos pueden tener importantes implicaciones para las políticas públicas ambientales, orientadas al enverdecimiento del

transporte por carretera. En particular, las políticas no sólo deben centrarse en cómo convencer a la gente a comprar VHNEs, sino también cómo empujarlos a dejar de comprar o conducir vehículos convencionales. Es cierto que el plan *Pive* pretende reemplazar los vehículos viejos por nuevos vehículos eficientes, pero estas ayudas monetarias no son suficientes (ni en cantidad ni en número); Por lo tanto, se necesitan políticas adicionales. En general, las políticas ambientales deben ser más agresivas hacia los vehículos convencionales.

CONCLUSIONES

En general se ha encontrado que la elección de vehículos disminuye con el precio, el consumo de combustible y las emisiones, pero aumenta con la adaptación a funcionar con biocombustibles. Además, los resultados muestran que las preferencias por los VHNEs y sus atributos son heterogéneas a varios niveles, lo que sugiere que los incentivos públicos deben adaptarse de acuerdo a estas diferencias. Además, se han detectado conceptos erróneos sobre los VHNEs, lo que demuestra la necesidad de acompañar los incentivos actuales con campañas de promoción para alcanzar los objetivos esperados. Los resultados muestran que actualmente la difusión de los VHNEs depende de los subsidios públicos; Sin embargo, apoyar su adopción con otros incentivos, como el pase de estacionamiento gratis combinado con restricciones a los vehículos regulares (impuestos, limitar su uso en ciudades, etc.) puede aumentar el uso de VHNEs. También es importante tener en cuenta las características de los vehículos actuales de los conductores cuando se implementan nuevas estrategias dado que las preferencias se forman alrededor de los vehículos actuales. En pocas palabras, las conclusiones sugieren que la reducción de las emisiones de transporte por carretera necesita más apoyo a los VHNEs y otras restricciones a la compra de vehículos convencionales. Las experiencias de otros países demostraron que la mezcla de varias estrategias puede cambiar la tendencia a favor de los VCAs. Por ejemplo, en Noruega, los vehículos eléctricos (VEs) tienen precios similares a los vehículos convencionales debido a incentivos públicos, incluida la exención del IVA (25% del precio), exención de los impuestos de matriculación (muy altos para los vehículos convencionales), acceso a los carriles de autobuses y de taxis, exención de pago de peajes, estacionamiento gratuito, viaje gratuito en los transbordadores, recarga municipal gratuita, reducciones en la tarifa de conducción anual (73\$ contra 524\$ para los vehículos regulares), y la exención del impuesto de la compañía. Como resultado, los VEs

representan más del 20% del total de vehículos nuevos vendidos en Noruega (Phillips, 2015). Por otra parte, el sistema francés bonus-malus, que recompensa la adopción de vehículos con bajos impactos ambientales y castiga la compra de vehículos con altos impactos ambientales (Withana et al., 2014) podría ser de gran ayuda para fomentar la adopción de VCAs. El sistema bonus-malus ofrece un super-bono de 10,000€ (frente a 1,500€ en el Plan *Pive* español) para el desguace de un vehículo diésel de más de 10 años, un bono que oscila entre 150€ para vehículos nuevos con emisiones de CO₂ de 61-90g a 6,300€ para la compra de un vehículo nuevo con emisiones de CO₂ inferiores a 20g/km y un impuesto que oscila entre 150€ para los vehículos con emisiones de CO₂ de 131 a 135g/km a 8,000€ para los vehículos con emisiones de CO₂ superiores a 200g/km. Como resultado, las emisiones de los nuevos turismos registrados en Francia disminuyeron en 19g/km entre 2007 (año de la introducción) y 2010 (Rubik y Mityorn, 2011). Además, limitar el acceso de vehículos convencionales a ciudades o áreas verdes puede ser otro fuerte incentivo para que los compradores opten por VCAs. Otro inconveniente a resolver es la desconfianza y la falta de familiaridad de los conductores con VCAs, mejorando así su presencia en las ciudades (por ejemplo, entre taxistas) generaría un nuevo estímulo visual alentando a más personas a querer conducirlos.

La presente tesis ofrece sugerencias sobre cómo mejorar las políticas públicas dirigidas a promover el uso de VHNEs, y cómo cambiar las decisiones de los conductores sobre la elección de vehículos a favor de los VCAs.

REFERENCIAS

Adler, Thomas Wargelin, Laurie Kostyniuk, Lidia Kavalec, Chris and Gary Occhiuzzo 2003. Incentives for alternative Fuel Vehicles: A Large-Scale Stated Preference Experiment, paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, August 2003.

Asociación Española de Fabricantes de Automóviles y Camiones (ANFAC), 2017. http://www.anfac.com/estadisticas.action?accion=estad_turismos (accessed 12.01.17).

Axsen, J., Mountain, D.C., Jaccard, M., 2009. Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles. *Resource and Energy Economics* 31(3), 221–238.

Baker, M., Pan, X., Wurgler, J., 2012. The effect of reference point prices on mergers and acquisitions. *Journal of Financial Economics* 106, 49-71.

Banerji, A., Gupta, N., 2014. Detection, identification, and estimation of loss aversion: Evidence from an auction experiment. *American Economic Journal: Microeconomics* 6 (1), 91-133.

Bartling, B., Brandes, L., Schunk, D., 2015. Expectations as Reference Points: Field Evidence from Professional Soccer. *Management Science* 61, 2646-2661.

Beck, M.J., Rose, J.M., Hensher, D.A., 2013. Environmental attitudes and emissions charging: An example of policy implications for vehicle choice. *Transportation Research Part A* 50, 171-182.

Becker, G.S., 1976. *The Economic Approach to Human Behavior*. Chicago: University of Chicago Press.

Beshears, J., Choi, J.J., Laibson, D., Madrian, B.C., 2008. How are preferences revealed? *Journal of Public Economics* 92, 1787–1794.

Choo, S., Mokhtarian, P.L., 2004. What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice. *Transportation Research Part A* 38, 201-222.

Chua, W.Y., Lee, A., Sadeque, S., 2010, Why do people buy hybrid cars?, in *Proceedings of Social Marketing Forum*, University of Western Australia, Perth, Western Australia , Edith Cowan University, Churchlands, W.A., pp. 1-13.

Daly, A., Hess, S., Train, K., 2012. Assuring finite moments for willingness to pay in random coefficient models. *Transportation* 39, 19-31.

De Borger, B., Fosgerau, M., 2008. The trade-off between money and travel time: A test of the theory of reference-dependent preferences. *Journal of Urban Economics* 64, 101–115.

Dhar, R., 1997. Consumer Preference for a No-Choice Option. *Journal of Consumer Research* 24, 215–31.

European Commission, 2016. Paris Agreement. Climate Action. http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm (assessed 28/07/2016).

Heath, C., Larrick, R. P., Wu, G., 1999. Goals as reference points. *Cognitive Psychology* 38, 79-109.

Heffner, R.R., Kurani, K.S., Turrentine, T.S., 2007. Symbolism in California's early market for hybrid electric vehicles. *Transportation Research Part D: Transport and Environment* 12 (6), 396-413.

Hess, S., Fowler, M., Adler, T., Bahreinian, A., 2012. A joint model for vehicle type and fuel type choice: evidence from a cross-nested logit study. *Transportation* 39 (3), 593–625.

Hess, S., Rose, J.M., Hensher, D.A., 2008. Asymmetric preference formation in willingness to pay estimates in discrete choice models. *Transportation Research Part E* 44(5), 847–863.

Hjorth, K., Fosgerau, M., 2009. Determinants of the degree of loss aversion. *International Choice Modelling Conference*, Leeds (UK).

Hoen, A., Koetse, M.J., 2014. A choice experiment on alternative fuel vehicle preferences of private car owners in the Netherlands. *Transp. Res. Part A* 61, 199–215.

Hoffmann, A.O.I., Henry, S.F., Kalogeras, N., 2013. Aspirations as Reference Points: An Experimental Investigation of Risk Behavior over Time. *Theory and Decision* 75, 193-210.

Ito, N., Takeuchi, K., Managi, S., 2013. Willingness-to-pay for infrastructure investments for alternative fuel vehicles. *Transp. Res. Part D* 18 (1), 1–8.

Kahneman, D., Tversky, A., 1979. Prospect theory: An analysis of decisions under risk. *Econometrica* 47, 313–327.

Krupa, J.S., Rizzo, D.M., Eppstein, M.J., Brad Lanute, D., Gaalema, D.E., Lakkaraju, K., Warrender C.E., 2014. Analysis of a consumer survey on plug-in hybrid electric vehicles. *Transportation Research Part A: Policy and Practice* 64, 14-31.

Lanz, B., Provins, A., 2012. Do status quo choices reflect preferences? Evidence from a discrete choice experiment in the context of water utilities' investment planning. *CEPE Working Paper No. 87*.

Link, C., Raich, U., Sammer, G., Stark, J., 2012. Modeling demand for electric cars – a methodical approach *Proc. Soc. Behav. Sci.* 48, 1958–1970.

Meyerhoff, J., Liebe, U., 2009. Status Quo Effect in Choice Experiments: Empirical Evidence on Attitudes and Choice Task Complexity. *Land Economics* 85 (3), 515–528.

Phillips, L., 2015. Norway's electric vehicle revolution: Lessons for British Columbia. Pacific Institute for Climate Solutions (PICS), Briefing Note 2015 – 43.

Potoglou, D., Kanaroglou, P. S., 2007. Household demand and willingness to pay for clean vehicles. *Transportation Research Part D: Transport and Environment* 12 (4), 264–274.

Rubik, F., Mityorn, L., 2011. CO₂-based Motor Vehicle Tax. Institute for Ecological Economy Research, The SCP-Knowledge Hub: 30 September 2011.

Samuelson, W., Zeckhauser, R., 1988. Status quo in decision making, *Journal of Risk and Uncertainty* 1, 7–59.

Stern, N. 2007. *The economics of climate change: The stern review*. Cambridge, UK: Cambridge University Press.

Thatchenkery, S.M., Beresteanu, A., 2008. Determinants of Automobile Demand and Implications for Hybrid-Electric Market Penetration. Honors thesis submitted in partial fulfilment of the requirements for Graduation with Distinction in Economics in Trinity College of Duke University.

Tversky, A., Kahneman, D., 1981. The framing of decisions and the psychology of choice. *Science* 211, 453–458.

Tversky, A., Kahneman, D., 1992. Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty* 5 (4), 297–323.

Withana, S., ten Brink, P., Illes, A., Nanni, S., Watkins, E., Lopez, A., van Dijk, E., Kretschmer, B., Mazza, L., Newman, S., Russi, D., 2014. Annexes to Final Report - Environmental tax reform in Europe: Opportunities for the future, A report by the Institute for European Environmental Policy (IEEP) for the Netherlands Ministry of Infrastructure and the Environment. Annexes to Final Report. Brussels. 2014.

Ziegler, Andreas. 2012. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. *Transportation Research Part A: Policy and Practice* 46 (8), 1372-1385.





INTRODUCTION





I. INTRODUCTION

I.1 INTRODUCTION

At the last United Nations Climate Change Conference (COP 21), celebrated in Paris, 195 countries committed to limit the increase in global average temperature below 2°C above pre-industrial levels. Specially, the European Union (EU) expressed its intentions to reduce emissions by at least 40% by 2030 compared to 1990 levels, as well as renewable energy and energy efficiency targets of at least 27% (European Commission, 2016). In the last years, EU has launched several measures to address the problem of climate change and to reduce the dependence on foreign petroleum, particularly of road transport. Hence, most of EU energy and environmental policies are directed to achieve high energy efficiency and low environmental impacts through improvement of internal combustion engines, and promoting the use of alternative fuel vehicles (AFVs) such as biofuel vehicles (BVs), electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs), among others. However, despite the fact that the presence of these technologies in the automotive industry has increased considerably in the last years, the reluctance of drivers towards AFVs remains very high. Stern (2007) suggested that energy and climate policy success involves not only producing low-carbon technology (technology policy) and making unattractive fossil fuels (carbon pricing policy), but also improving energy decisions and behaviors of drivers (behavioral change policy). Therefore, it would be interesting to identify and to understand the determinant factors that drive vehicle choice decisions to change drivers' behaviors or to nudge them toward AFVs; especially HEVs which are the focus of the present research. In particular, drivers' preferences for specific vehicle attributes, preference structure, taste variations, vehicle size effect, monetary and no-monetary incentive effects, and the effect of reference points on drivers' decision making process have received a special attention in the present dissertation.

Most of existing literature (Beck et al., 2013; Chua et al., 2010; Heffner et al., 2007; Hess et al., 2012; Hoen and Koetse, 2014; Ito et al., 2013; Krupa et al., 2014; Link et al., 2012; Potoglou and Kanaroglou, 2007; Thatchenkery and Beresteanu, 2008; Ziegler, 2012) has attributed a rise on AFVs choice to performance, horsepower, fuel savings, number of doors or seats, autonomy, fuel availability, public incentives (tax exemptions or reductions); whereas a decrease in demand was related to price, fuel consumption costs, maintenance costs, emissions, and recharging time. Mixed results have been found regarding choices among different vehicle types. While some studies (Hoen and Koetse, 2014; Link et al., 2012; Ziegler, 2012) showed that conventional vehicles are preferred over AFVs, others (Hess et al., 2012; Ito et al., 2013) reported that at list some kind of AFVs are preferred to conventional vehicles. Moreover, preferences for HEVs are found to be influenced positively by high income, higher educational level, environment awareness (Potoglou and Kanaroglou, 2007; Thatchenkery and Beresteanu, 2008), annual mileage (Ziegler, 2012), different symbolic meanings associated with HEVs including achieving certain social image (Chua et al., 2010), and owning the latest technology (Heffner et al., 2007); and negatively influenced by age, and being a male (Link et al., 2012). Furthermore, Axsen et al. (2009) demonstrated the role of neighbor effects in the demand for HEVs, affirming that higher HEV penetration yielded higher demand and willingness to pay for HEVs. Most of the previous cited literature are carried out in North America (Axsen et al., 2009; Heffner et al., 2007; Potoglou and Kanaroglou, 2007; Thatchenkery and Beresteanu, 2008) where HEVs are much more popular than in Europe. In Spain, among the 1,147,007 passenger vehicles sold in 2016, only 2.70% were hybrid vehicles (HEVs and PHEVs) (ANFAC, 2017). Additionally, Choo and Mokhtarian (2004) reported that owners of different vehicle size have different preferences and attitudes. Therefore, taste variations for vehicle types and attributes according to vehicle size should be analyzed.

There are still many unknowns about the vehicle choice decision making process. Most of traditional economic theories (Becker, 1976) considered that people behave rationally (maximize their utility), whereas more recent behavioral approaches (Samuelson and Zeckhauser, 1988; Tversky and Kahneman, 1981) showed that choice decision may also be subject to non-rational cognitive factors such as the status quo, the reference point, or simply

loss aversion. The Kahneman and Tversky (1979)'s prospect theory extended to cumulative prospect theory (Tversky and Kahneman, 1992) has been built to explain this conflict. It stipulates that individuals assess goods balancing their gains and losses relatively to a given reference point, and weighted losses more than corresponding gains, denoting such behavior as loss aversion. Reference dependence is the main pillar of prospect theory because utilities are defined around the reference point. Therefore, it is vital to identify and to take into account the appropriate reference point that individuals consider when making a choice. Previous concepts have been tested and supported in trip choices (De Borger and Fosgerau, 2008; Hess et al., 2008; Hjorth and Fosgerau, 2009) but rarely in vehicle choices and even less in the context of discrete choice experiments (DCEs), where a reference point (status quo) option is often included to make the choice situations more realistic. The election of the status quo option may reflect preference for the current situation (Lanz and Provins, 2012), or simply avoiding complex choices (similar alternatives) to reduce mental and emotional efforts (Beshears et al. 2008), avoiding possible regret (Samuelson and Zeckhauser, 1988), protesting (Meyerhoff and Liebe, 2009), while continuing checking for the best option (Dhar, 1997). Many times, the status quo no-choice option is substituted by a constant option defined as the current situation, goals (Heath et al., 1999), aspirations (Hoffmann et al., 2013), expectations (Bartling et al., 2015; Banerji and Gupta, 2014), and past acquisitions (Baker et al., 2012) among others, which leads to different estimates. Thus, it would be important to provide further clarification on this process to improve the behavioral understanding and prediction through DCEs.

Moreover, choice behavior analyses are often carried out using a multinomial logit model (MNL) which is a very restrictive model. Under the independence of irrelevant alternatives (IID) assumption, the MNL assumes fixed tastes across respondents, alternatives and over time, which is not always a realistic assumption. People are different and therefore they would have different tastes. In addition, in the context of DCE, each individual faces multiple choice decisions, so that his repeated responses are more likely to be correlated over time (across choice sets) and amongst attributes and alternatives (in a given choice set). Capturing heterogeneity associated with observed and unobserved effects is crucial to improve the understanding of people's preferences. Therefore, it would be very interesting to analyze the

heterogeneity in preferences at several levels through the use of more flexible discrete choice models.

The present dissertation is justified by the need of an additional understanding of the rational and irrational factors which drive vehicle choice decisions. The aim is to improve predictions of drivers' preferences and better account for the role of environmental policies directed to enhance the use of AFVs, especially HEVs. The present analysis focuses on HEVs because in addition to the fact that these vehicles do not suffer the limitations due to the batteries, they are sold more than PHEVs in Spain.

I.2 OBJECTIVES AND MAIN RESULTS

The main aim of the present dissertation is to explore the relevant factors that drive people vehicle choice decisions, especially those that are key to prefer HEVs to conventional vehicles. HEVs are still not popular in Spain; thereby it is not clear the role they would have in replacing conventional technologies in the near future. In this context, preferences for HEV and its attributes are assessed among 1,016 Spanish drivers. In particular, tastes for vehicle type, price, fuel consumption, CO₂ emissions and biofuel adaptation have been elicited based on online DCEs. This dissertation is organized into four empirical chapters that have different focuses and objectives.

The first Chapter analyses the choice of small and midsize vehicles and has the following specific objectives:

1. To test whether drivers with stronger preferences towards incentives based on price reductions via subsidies, tax breaks (in the registration fees), free parking, access to priority lanes and reputational incentives would be more likely to select HEVs. In other words, do drivers consider these incentives when buying HEVs?
2. To test whether different individuals perceive differently HEVs and vehicle attributes. Studies often ignored individual heterogeneities when assessing preferences for AFVs, which is an unrealistic assumption, given that different individuals may behave differently. Therefore, it will be interesting to address this point using more flexible

discrete choice analysis which allows preferences to be heterogeneous across the sampled drivers.

3. To assess drivers' willingness to pay (WTP) for a HEV, a vehicle with high energy efficiency and low environmental impacts, and which is adapted to run with biofuels. Several studies estimated WTPs for AFVs but they often ignored to derive their distributions. Even when dealing with distributions, often it was made in a way not very suitable or completely inappropriate (see Daly, et al., 2012). Sometimes the problem is based on the assumed distributions for the parameters. In many studies the monetary parameter is kept fixed (ignoring the dispersions), while in other occasions distributions are assumed for certain attributes allowing positive and negative preferences for such attributes, although perhaps for one of these two directions these are not reasonable expectations. Moreover, sometimes the problem consists in the frameworks used to estimate the WTPs. In particular, when the WTP ratio is a division of two distributions, the use of the Delta or Krinsky-Robb method to construct the distribution of the WTPs may be inappropriate because the WTP distributions might not have finite moments for certain combinations of distributions in the WTP ratio (Daly, et al., 2012). Thus, it is interesting to carry out an analysis where the most appropriate distributions will be assumed for the parameters associated with the attributes and where a simulation method which guarantees the existence of finite moments for the WTP distributions is applied.

Overall, it is found that drivers have clear misconceptions about HEVs. Results show that drivers who give greater importance to both free parking pass and social image are more likely to select HEVs, implying that offering free parking space and promoting the green image associated with HEVs may help people to opt for HEVs. Similarly, and in agreement with findings from previous studies (Achtnicht et al., 2012; Hackbarth and Madlener, 2016; Potoglou and Kanaroglou, 2007; Ziegler, 2012), results reveal that people prefer vehicles with low price, low fuel consumption, low emissions, and vehicles able to run with biofuels. Further, an important heterogeneity in preferences for vehicle attributes is found across the sampled drivers, showing that public incentives should be customized according to taste differences. Moreover, in *ceteris paribus* conditions, drivers are more likely to pay a premium for a vehicle with high energy efficiency and low environmental impacts, and which is

adapted to run with biofuels but not for the fact to be a HEV. Therefore, current policies based on economic subsidies applied in isolation to promote these types of vehicles may have a limited effect in extending their use. Hence, a policy mix of various incentives (including informational campaigns) may be required.

The second Chapter also focuses on the choice of small and midsize vehicles and looks for answers to the following specific objectives:

1. To analyze heterogeneity in preferences for vehicle type and its attributes among different groups of drivers, previously identified using a latent class model (LCM).
2. To identify drivers' groups who are more aware of environmental issues and those who are more likely to buy HEVs.
3. To know the willingness of each drivers' group to make an economic effort to adopt HEVs.

Results identify 4 groups (or classes) of individuals whose preferences are different between each other. The heterogeneity was manifested by the relative importance given to the different vehicle attributes, the number and the order of the attributes that drive vehicle choices. In particular, findings show that HEVs are significantly preferred for two groups of drivers, although one of them prefers HEVs in part for reputational incentives; whereas the two other groups do not appreciate HEVs with respect to conventional vehicles, *ceteris paribus*. Findings may serve as a guide to design accurate strategies for promoting sustainable transportation technologies and address them to the right target population.

The third Chapter compares the way drivers behave when they choose between small/midsize vehicles and large vehicles. This Chapter has the following specific objectives:

1. To analyze differences in preferences for vehicle type and its attributes according to vehicle size. Specifically, it compares preferences of two groups of drivers: future drivers of a small/midsize vehicle model and those who are likely to buy a large vehicle model. Previous studies (Krupa et al., 2014), showed that vehicle size influences vehicle choice but never examined how tastes for vehicle attributes changed according to vehicle size.

2. To check whether drivers of larger vehicles are less environmental sensitive than drivers of small/midsize vehicle.
3. To test whether differences in preferences for attributes result in differences in the willingness-to-pay (WTP) for the attributes. Thus, a special interest is given to these issues in this Chapter.
4. To capture additional heterogeneity in preferences across drivers, alternatives, attributes and over time. These additional sources of heterogeneity are often ignored in studies but they are very important to understand better drivers' preferences.

Results provide evidence of Spanish preferences for small/midsize vehicles over large vehicles and for HEVs over conventional vehicles. Moreover, it is found that drivers of large vehicles have a pattern of preferences for environment attributes identical to that of drivers of small/midsize vehicles. Furthermore, the preferences of drivers of small/midsize vehicles are more heterogeneous than those of drivers of large vehicles. In addition, drivers are not, *ceteris paribus*, willing to pay a premium for HEVs compared to conventional vehicles, independently of vehicle size. However, drivers are likely to pay a premium for a vehicle with low fuel consumption cost, low emissions and which is adapted to run with biofuels. Findings suggest that drivers do not associate reductions in fuel consumption and CO₂ emissions with HEVs. Therefore, public promotion of these improvements may increase demand for HEVs.

The fourth Chapter addresses the role of reference point in a DCE applied to assess preferences for small/midsize vehicles. The specific objectives of this Chapter are:

1. To test the effect of the reference point, often ignored when analyzing choices, particularly those made in the context of DCEs.
2. To identify the most accurate reference point considered by drivers when buying a new vehicle; especially in a discrete choice experiment (DCE) context. In particular, three different individual reference points have been tested.
3. To test how reductions in price, fuel consumption and environmental impacts of the new offered vehicles compared to current vehicles influence individuals' preferences.

Overall, it was demonstrated that the empirical models are affected by reference points, and ignoring such effect leads to biased predictions. Furthermore, results show that vehicle

preferences are formed around drivers' current vehicle (status quo). Findings suggest that not considering the status quo option properly may bias the results and reduces the ability of DCEs to explain drivers' real preferences. These findings may have important implications for public environment policies, aimed at greening road transport. In particular, policies should not only focus on how to convince people to buy HEVs but also how to push them to stop buying or running with conventional vehicles. It is true that the *Pive* plan aims to replace old vehicles with new efficient vehicles but these monetary aids are not enough (neither in amount nor in number); therefore additional policies are needed. In general, environment policies should be more aggressive toward conventional vehicles.

I.3 CONCLUSIONS

Overall it is found that vehicle choice decreases with price, fuel consumption, and emissions but increases with the adoption of vehicles to run with biofuels. Furthermore, findings show that preferences for HEVs and its attributes are heterogeneous at several levels, suggesting that public incentives should be adapted according to these differences. Moreover, clear misconceptions about HEVs have been detected, showing the need of accompanying the current incentives with promotional campaigns to meet the expected objectives. In addition, results show that at the moment, the diffusion of HEVs depends on the public subsidies; however, supporting their adoption with other incentives, such as free parking combined with restrictions on regular vehicles (taxes, limits to their use in cities, etc.) may increase their use. It is also important to take into account the characteristics of the current vehicles when new strategies are implemented, given that preferences are formed around current vehicles. Briefly, findings suggest that reducing road transport emissions needs more support for AFVs in addition to other restrictions towards the purchase of conventional vehicles. Experiences of other countries demonstrated that mixing several strategies may change the trend in favor of AFVs. For example, in Norway, EVs have similar prices with respect to conventional vehicles due to public incentives, including VAT exemption (25% of the price), no registration taxes (extremely high for conventional vehicles), access to bus and taxi lanes, free toll roads, free parking, free travel on ferries, free municipal recharging, reductions in annual driving fee (\$73 versus \$524 for regular vehicles), and exemption from company car tax. As a result, EVs represent more than 20% of the total of new vehicles sold in Norway (Phillips, 2015).

Moreover, the French bonus-malus system which rewards the adoption of vehicles with low environmental impacts and punishes the purchase of vehicles with high environmental impacts (Withana et al., 2014) could be of great help to encourage the adoption of AFVs. The bonus-malus system offers a €10,000 (versus to €1,500 in the Spanish *Pive* Plan) super-bonus for scrapping a diesel vehicle over 10 years-old, a bonus ranging from €150 for new vehicles with CO₂ emissions of 61-90g to €6,300 for the purchase of new vehicle with CO₂ emissions of less than 20g/km, and a fee ranging from €150 for vehicles with CO₂ emissions of €131-135g to €8,000 for vehicles with CO₂ emissions exceeding 200g/km. As a result, the emissions of new registered passenger vehicles in France fall by 19g/km between 2007 (the year of the introduction) and 2010 (Rubik and Mityorn, 2011). Also, limiting the access of conventional vehicles to cities or green areas may be another strong incentive for buyers to opt for AFVs. Another drawback to solve is the distrust and the unfamiliarity of drivers with AFVs, thus improving their presence in cities (for example among taxi drivers) would generate a new visual stimulus encouraging more people to want to drive them.

The present dissertation provides suggestions on how to improve public policies aimed to promote the use of HEVs, and how to change drivers' vehicle choice decisions towards AFVs.

I.4 REFERENCES

Achtnicht, M., 2012. German car buyers' willingness to pay to reduce CO2 emissions. *Climatic Change* 113(3-4), 679-697.

Asociación Española de Fabricantes de Automóviles y Camiones (ANFAC), 2017. http://www.anfac.com/estadisticas.action?accion=estad_turismos (accessed 12.01.17).

Axsen, J., Mountain, D.C., Jaccard, M., 2009. Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles. *Resource and Energy Economics* 31(3), 221–238.

Baker, M., Pan, X., Wurgler, J., 2012. The effect of reference point prices on mergers and acquisitions. *Journal of Financial Economics* 106, 49-71.

Banerji, A., Gupta, N., 2014. Detection, identification, and estimation of loss aversion: Evidence from an auction experiment. *American Economic Journal: Microeconomics* 6 (1), 91-133.

Bartling, B., Brandes, L., Schunk, D., 2015. Expectations as Reference Points: Field Evidence from Professional Soccer. *Management Science* 61, 2646-2661.

Beck, M.J., Rose, J.M., Hensher, D.A., 2013. Environmental attitudes and emissions charging: An example of policy implications for vehicle choice. *Transportation Research Part A* 50, 171-182.

Becker, G.S., 1976. *The Economic Approach to Human Behavior*. Chicago: University of Chicago Press.

Beshears, J., Choi, J.J., Laibson, D., Madrian, B.C., 2008. How are preferences revealed? *Journal of Public Economics* 92, 1787–1794.

Choo, S., Mokhtarian, P.L., 2004. What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice. *Transportation Research Part A* 38, 201-222.

Chua, W.Y., Lee, A., Sadeque, S., 2010, Why do people buy hybrid cars?, in *Proceedings of Social Marketing Forum*, University of Western Australia, Perth, Western Australia , Edith Cowan University, Churchlands, W.A., pp. 1-13.

Daly, A., Hess, S., Train, K., 2012. Assuring finite moments for willingness to pay in random coefficient models. *Transportation* 39, 19-31.

De Borger, B., Fosgerau, M., 2008. The trade-off between money and travel time: A test of the theory of reference-dependent preferences. *Journal of Urban Economics* 64, 101–115.

Dhar, R., 1997. Consumer Preference for a No-Choice Option. *Journal of Consumer Research* 24, 215–31.

European Commission, 2016. Paris Agreement. Climate Action. http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm (assessed 28/07/2016).

Hackbarth, A., Madlener, R., 2016. Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany. *Transportation Research Part A: Policy and Practice* 85, 89–111.

Heath, C., Larrick, R. P., Wu, G., 1999. Goals as reference points. *Cognitive Psychology* 38, 79-109.

Heffner, R.R., Kurani, K.S., Turrentine, T.S., 2007. Symbolism in California's early market for hybrid electric vehicles. *Transportation Research Part D: Transport and Environment* 12 (6), 396-413.

Hess, S., Fowler, M., Adler, T., Bahreinian, A., 2012. A joint model for vehicle type and fuel type choice: evidence from a cross-nested logit study. *Transportation* 39 (3), 593–625.

Hess, S., Rose, J.M., Hensher, D.A., 2008. Asymmetric preference formation in willingness to pay estimates in discrete choice models. *Transportation Research Part E* 44(5), 847–863.

Hjorth, K., Fosgerau, M., 2009. Determinants of the degree of loss aversion. *International Choice Modelling Conference*, Leeds (UK).

Hoen, A., Koetse, M.J., 2014. A choice experiment on alternative fuel vehicle preferences of private car owners in the Netherlands. *Transp. Res. Part A* 61, 199–215.

Hoffmann, A.O.I., Henry, S.F., Kalogeras, N., 2013. Aspirations as Reference Points: An Experimental Investigation of Risk Behavior over Time. *Theory and Decision* 75, 193-210.

Ito, N., Takeuchi, K., Managi, S., 2013. Willingness-to-pay for infrastructure investments for alternative fuel vehicles. *Transp. Res. Part D* 18 (1), 1–8.

Kahneman, D., Tversky, A., 1979. Prospect theory: An analysis of decisions under risk. *Econometrica* 47, 313–327.

Krupa, J.S., Rizzo, D.M., Eppstein, M.J., Brad Lanute, D., Gaalema, D.E., Lakkaraju, K., Warrender C.E., 2014. Analysis of a consumer survey on plug-in hybrid electric vehicles. *Transportation Research Part A: Policy and Practice* 64, 14-31.

Lanz, B., Provins, A., 2012. Do status quo choices reflect preferences? Evidence from a discrete choice experiment in the context of water utilities' investment planning. *CEPE Working Paper No. 87*.

Link, C., Raich, U., Sammer, G., Stark, J., 2012. Modeling demand for electric cars – a methodical approach *Proc. Soc. Behav. Sci.* 48, 1958–1970.

Meyerhoff, J., Liebe, U., 2009. Status Quo Effect in Choice Experiments: Empirical Evidence on Attitudes and Choice Task Complexity. *Land Economics* 85 (3), 515–528.

Phillips, L., 2015. Norway's electric vehicle revolution: Lessons for British Columbia. Pacific Institute for Climate Solutions (PICS), Briefing Note 2015 – 43.

Potoglou, D., Kanaroglou, P. S., 2007. Household demand and willingness to pay for clean vehicles. *Transportation Research Part D: Transport and Environment* 12 (4), 264–274.

Rubik, F., Mityorn, L., 2011. CO2-based Motor Vehicle Tax. Institute for Ecological Economy Research, The SCP-Knowledge Hub: 30 September 2011.

Samuelson, W., Zeckhauser, R., 1988. Status quo in decision making, *Journal of Risk and Uncertainty* 1, 7–59.

Stern, N. 2007. *The economics of climate change: The stern review*. Cambridge, UK: Cambridge University Press.

Thatchenkery, S.M., Beresteanu, A., 2008. Determinants of Automobile Demand and Implications for Hybrid-Electric Market Penetration. Honors thesis submitted in partial fulfilment of the requirements for Graduation with Distinction in Economics in Trinity College of Duke University.

Tversky, A., Kahneman, D., 1981. The framing of decisions and the psychology of choice. *Science* 211, 453–458.

Tversky, A., Kahneman, D., 1992. Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty* 5 (4), 297–323.

Withana, S., ten Brink, P., Illes, A., Nanni, S., Watkins, E., Lopez, A., van Dijl, E., Kretschmer, B., Mazza, L., Newman, S., Russi, D., 2014. Annexes to Final Report - Environmental tax reform in Europe: Opportunities for the future, A report by the Institute for

European Environmental Policy (IEEP) for the Netherlands Ministry of Infrastructure and the Environment. Annexes to Final Report. Brussels. 2014.

Ziegler, Andreas. 2012. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. *Transportation Research Part A: Policy and Practice* 46 (8), 1372-1385.



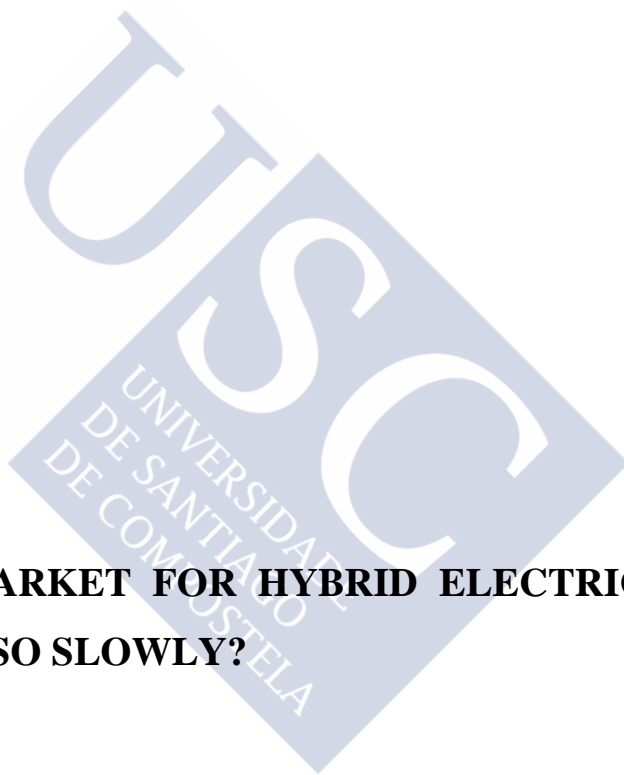
II. EMPIRICAL CHAPTERS





CHAPTER 1

WHY IS THE MARKET FOR HYBRID ELECTRIC VEHICLES (HEVs) MOVING SO SLOWLY?





1. WHY IS THE MARKET FOR HYBRID ELECTRIC VEHICLES (HEVs) MOVING SO SLOWLY?

Abstract

A survey is conducted in a representative sample of Spanish drivers in order to assess whether drivers with stronger preferences towards incentives based on price reductions via subsidies, tax breaks (in the registration fees), free parking, access to priority lanes and reputational incentives would be more likely to select a hybrid electric vehicle (HEV) or a new conventional vehicle. Results show that drivers who give greater importance to both free parking and social image are more likely to select a HEV. Further, drivers are not, *ceteris paribus*, willing to pay an extra for the HEVs compared to conventional vehicles, but they are likely to pay a premium for vehicles with low fuel consumption, low environmental impacts, and for flex-fuel vehicles. Overall, it is found that drivers have clear misconceptions about HEVs. Therefore, a policy mix of various incentives (including informational campaigns) may be required in order to stimulate domestic demand for HEVs.

1.1 INTRODUCTION

In December 2015, a total of 195 countries approved a universal agreement to combat climate change at the Climate Summit in Paris (COP 21), where they expressed their willingness to move together towards a low carbon economy. The European Union (EU) has announced its plan to achieve its ambitious challenges, including the reduction of its greenhouse gas emissions by 40% by 2030 from the 1990 level; improving energy efficiency by 40%; and increasing the contribution of renewable energy in its energy consumption by 27% (European Commission, 2015).

One of the priorities is the transport sector, due to its significant contribution to global warming, and air pollution (Directive 2009/28/EC; 2009/30/EC; Directive 2009/33/EC). In particular, road transport is a major source of greenhouse gas emissions in European cities, being responsible for one fifth of the EU's total emissions of carbon dioxide (CO₂), the main greenhouse gas. Despite a slight decrease in the last few years, these emissions are still 20.5% higher than in 1990 (European Commission, 2012). The consequences of air pollutants generated by the transport sector on human health are an increasing cause for concern. According to the European Commission (2013), air pollution causes the premature death of more than 400,000 people in Europe every year. In 2011, Ecologists in Action revealed that many Spanish cities were affected by air pollution, indicating that 94% of Spaniards are breathing air whose quality does not meet the safe pollution levels recommended by the World Health Organization (Ecologists in Action, 2011).

The current economic crisis has resulted in the Spanish vehicle fleet being one of the oldest in Europe, currently with an average car age of 11.3 years. Vehicles older than 10 years account for 50% of all cars circulating in Spain, while in Italy they represent 40%, 35% in Germany, and around 30% in the UK (ANFAC, 2014). Driving vehicles of this kind multiplies the environmental damage caused by road transport. In this context, various strategies have been promoted in Spain, including the *Movele* and the *Pive* public programs, both aimed at promoting the market adoption of efficient cars. The *Pive* program is designed to encourage the acceptance of efficient conventional vehicles, hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), electric vehicles (EVs), extended range electric vehicles and flex-fuel (using liquefied petroleum gas or natural gas) vehicles. However, up to now, and despite the existence of various stimuli, the market penetration for both HEVs and PHEVs is still quite low in Spain. This study explores the potential reasons behind such a low adoption rate.

A HEV (non-plugin) is an alternative vehicle which uses internal combustion engines and electric batteries. It uses braking energy, which is normally wasted, to recharge the battery. Granovskii et al. (2006) showed that HEVs offer economic and environmental advantages over conventional cars, *ceteris paribus*. For example, the cheapest HEV from Toyota achieves

reductions in CO₂ emissions of about 15gCO₂/km and fuel savings from 1 to 1.7 l/100km, in comparison to its conventional models (Toyota, 2016).

Currently, the *Pive* program (IDAE, 2015) offers a discount of €1,500 on the purchase of a new vehicle, after turning in a private car over 10 years of age, or any commercial vehicle over 7 years of age. The vehicle purchased must be new, with emissions of 120g per 1 km or less, or a more efficient model (EVs, HEVs, PHEVs, or using alternative fossil fuels). As a result, the institute for the diversification and energy saving (IDAE) estimated that from 2012 to 2014 the *Pive* plan has led to the replacement of 715,000 old vehicles, saved 248 million litres of fuel per year, and reduced greenhouse gas emissions by 513,000 tons of CO₂ per year (IDEA, 2015).

The Spanish government also reformed the car registration tax (Law 34/2007 of 15th of November on air quality and protection of the atmosphere), making it inversely proportional to the amount of CO₂ emissions (0% for emissions lower than 120 g/km, 4.75% of the value of the car for emissions between 120 and 160 g/km, 9.75% for emissions of between 160 and 200 g/km; and finally, 14.75% for emissions of 200 g/km or higher).

In spite of these current public policy efforts to encourage drivers to adopt hybrid cars (HEVs and PHEVs), these are still not particularly popular in the Spanish market. In 2016, hybrid cars only accounted for 2.70% of new passenger car sales (most were HEVs) (ANFAC, 2017). The Japanese Toyota brand led the sales of hybrid cars in Spain, with a market share of more than 70%. Together with its premium brand Lexus, they accounted more than 80% of the total hybrid cars sold in Spain in 2016. While the vast majority of hybrid cars sold were gasoline, diesel hybrid cars only represented 6% of the total units sold (ANFAC, 2017). The prices of HEVs vary significantly between models and brands. In general, these hybrid models cost between €3,000 and €5,000 more than their corresponding conventional models (Toyota, 2016).

Up to now, it has not been clear why drivers have avoided switching to HEVs. Is it primarily related to their price? And if so, what kind of incentive is needed to encourage drivers to switch to HEVs? Or is it based on other misconceptions and concerns associated

with HEVs that may be more important than the price markup? Based on a discrete choice experiment (DCE) included in an extensive online questionnaire, the present Chapter aims to provide some insight into these questions for the Spanish context, as well as the type of incentives that are required in order to galvanize the HEV market. Specifically, it explores preferences towards car attributes, including fuel consumption and CO₂ emissions (improved in HEVs). In addition, it tests whether drivers' perceptions towards public policies based on economic incentives (such as subsidies, reductions in registration taxes, access to free parking, and access to priority lanes), as well as reputational mechanisms (such as social image of the driver) would encourage demand for HEVs. Finally, individual heterogeneity in preferences for car attributes, including the price –a factor that is often overlooked– is considered by specifying a random parameter logit (RPL) model.

1.2 LITERATURE REVIEW

There is a wide range of existing literature on car choices. Some studies have explored consumers' preferences only for EVs (Hidrue et al., 2011; Jabeen, 2011; Wu et al., 2013; Zhang et al., 2011). In general, they have focused on the effect of car characteristics related to the problems of the batteries (driving range, charging time, battery cost, and fuel availability) and the power of the EVs (performance). They signaled the importance of reducing their prices, and solving battery problems in order to promote this alternative fuel technology.

Other contributions explored consumers' preferences for different alternative fuel vehicles (AFVs) including EVs, HEVs, PHEVs, liquefied petroleum gas, compressed natural gas, biofuel, and hydrogen powered vehicles (Achtnicht, 2012; Caulfield et al., 2010; Ewing and Sarigöllü, 1998; Nixon and Saphores, 2011; Potoglou and Kanaroglou, 2007; Qian and Soopramanien, 2011). This line of studies explored the differences between the individual utility attributed to each one of the AFVs. The results detected heterogeneous individual perceptions for different AFVs, with conventional cars remaining the most attractive option.

From the extensive existing literature on car choices, few studies (Axsen et al., 2009; Chua et al., 2010; Erdem et al., 2010; Heffner et al., 2007; Thatchenkery and Beresteanu, 2008) have specifically investigated consumers' preferences for hybrid cars (HEVs or

PHEVs). Erdem et al. (2010) used a contingent valuation method to estimate willingness to pay (WTP) for HEVs in Turkey. The results showed that people were willing to pay an average premium of US\$ 858 to change to a HEV. The highest WTP for a HEV was stated mainly by men who were highly educated, wealthy, environmentally aware, risk seekers, with high level of awareness of HEVs, who positively perceived AFVs, and who were first or second to acquire an innovation. Thatchenkery and Beresteanu (2008) explored HEV demand in the USA using the United States 2006 Polk New Vehicle Registration Cross-sectional Data. They showed that people were sensitive to fuel efficiency, but were more sensitive towards horsepower and weight. Axsen et al. (2009) combined the revealed preferences (recent car purchases) and stated preferences of Canadian and Californian car owners to explore how consumer preferences for HEVs have shifted (specifically the neighbor effect) as HEV market penetration increased. The results showed that the WTP for HEVs rose with the market share. Chua et al. (2010) employed scales and items to compare HEV and conventional car buyers in Australia. The results from factor analysis showed that while preferences for conventional cars were more sensitive to variations in quality and performance, and less sensitive to image and social influence, HEV buyers placed a great amount of importance on their 'green' image and social influence, and little importance on quality and appeal. Heffner et al. (2007) used informal face-to-face interviews to investigate whether the 'green' social image influenced United States households to adopt HEVs. The results showed that all HEV owners placed some importance on the 'green' image of their cars, although they did not adopt HEVs by only focusing on their image. The present research joins this line of studies by adding a number of contributions. First, this study assesses the heterogeneity of preferences for car attributes across drivers. Second, this study investigates the importance of incentives when buying efficient cars, and explores whether these incentives increase the demand for HEVs.

1.3 SURVEY DESIGN

Data were collected using an online survey directed to a representative sample of drivers over the age of eighteen. The survey was administered in July 2013 to 1,200 residents in Spain. The number of completed responses was 1,016 (response rate of 84.87%). A total of 878 drivers (86.41% of the completed surveys) expressed their desire to buy a small or midsize car in the future, while only 138 drivers (13.58% of the completed survey) stated their

wish to adopt a large size car in the future. In this paper, data from the survey completed by the drivers willing to buy a small and medium-size car is analyzed.

The survey first asked drivers to provide information about several car related issues, including current car(s) ownership, brand preferences, awareness of energy consumption issues, and their environmental attitudes. Next, the survey provided information about HEVs, asking about their intentions and plans for future car-purchases, including a DCE to elicit preferences to buy a future car. It concluded with the socio-demographic characteristics of the driver.

1.3.1 EXPERIMENTAL DESIGN AND DCEs

A DCE is used as it is the more appropriate way for measuring consumer welfare, and its results are more consistent with the economic theory than a traditional conjoint analysis (Louviere et al., 2010). In addition, HEVs have a small market share, and revealed preference data sources are still scarce. The DCE method is based on the assumptions of economic rationality and utility maximization (Hall et al., 2004). It consists of presenting drivers with several car alternatives, and asking them to choose one of them based on their preferences. Each individual is expected to choose the alternative that maximizes his/her utility. Moreover, the utility derived from an alternative is assumed to depend on the marginal utilities associated with its attributes (Lancaster, 1966). As a HEV is a quasi-public good, both economic attributes and environmental (non-economic) attributes are included. In the survey, and prior to the DCE exercise, participants were familiarized with HEVs and the expected consumption and emissions for a mid-size car. They were also required to assume that all non-specified attributes remained constant across alternatives. A DCE was then carried out, in which the participants could select between a regular vehicle and a HEV, or just remain with the status quo option (neither car).

Focus groups, pilot surveys and previous studies were used in order to identify the most relevant attributes and suitable levels for our DCE exercise. Previous studies (Potoglou and Kanaroglou, 2007) summarized the determinant factors of a car choice process mainly into economic attributes (purchase price, fuel cost), non-economic attributes (refueling or

recharging time, availability of fuel or recharging opportunities, technological performance), and environmental attributes (emissions). Besides the type of vehicle, two economic attributes have been included: price and fuel consumption, factors that are highly and primarily valued by drivers when considering the purchase of AFVs (Adler et al., 2003). Apart from the monetary attributes, each choice set included two non-monetary or environmental attributes. The environmental attributes included were carbon dioxide (CO₂) emissions, which was found to be significant in earlier studies (Potoglou and Kanaroglou, 2007), and the option of biofuel adaptation (flex-fuel), which is a recent trend in carmakers. In fact, European legislation (Directive 2003/30/EC) and national legislation (Spain's Royal Decree 61/2006) allow carmakers to incorporate bio-fuel directly into conventional fuel without the need for specific labeling, unless the proportion exceeds 5%. Some existing studies (Achtnicht, 2012; Hackbarth and Madlener, 2016) have explored preferences for biofuel cars, although it has never been investigated as an additional attribute to conventional and HEVs.

The attribute levels are based on information obtained from car suppliers in the Spanish market for small and midsize cars. This information is used to determine 2 levels of vehicle type (regular or HEV) and 3 levels of prices used in the analysis: a low price level (€12,000), a medium price level (€16,000) and a high price level (€20,000). The mid-price level considered corresponds to the average price of new cars sold in Spain in 2012. From 2009 to 2013, most of the new cars sold in Spain (80% of the total) were priced below €20,000, due in part to the decrease of purchasing power of consumers caused by the economic crisis. For these reasons, and given the focus of this work (analyzing the demand for small and medium HEVs), the upper price level is set at €20,000 and the lower price level at €12,000. The fuel consumption attribute was expressed as fuel cost (€) per 100 kilometers (Achtnicht, 2012; Ziegler, 2012). This unit is used because drivers tend to remember how much fuel their car consumes in terms of euros/kilometers. The fuel cost was computed as the product between the numbers of liters of fuel the vehicle would require to travel 100 kilometers, and the average fuel price in Spain (€1.35 per liter at the time of the study). Similarly, the CO₂ emissions were expressed as grams of CO₂ per kilometer (Achtnicht, 2012; Ziegler, 2012). Again, for simplicity, and for the purposes of this research, only two emission levels are included: a more efficient level (100gr per kilometer) and an inefficient level (150gr per

kilometer). Finally, the presence or absence of the potential of biofuel adaptation corresponded with the two dichotomous levels specified for the corresponding attribute.

The combination of these five attributes and their levels, using SPSS orthogonal main effects design and then the procedure of Street and Burgess (2007) (vector of differences = 12111), generated an optimal orthogonal design (OOD). The OOD is constructed so as to maximize the differences in the attribute levels across alternatives, and therefore, maximize the information from each respondent, forcing the tradeoffs of all attributes in the experiment (Street et al., 2005). It should note that this design fits best choices where each alternative has the same number of attributes, and each attribute has the same number of levels. The final design contained 8 choice cards with a design efficiency of 98%.

Each respondent was presented with a total of 8 choice cards, a reasonable number that does not affect data quality (Johnson and Orme, 1996). Figure 1.1 shows an example of a choice card. The no-choice alternative (neither car) was provided in order to make the choice decisions very similar to market decisions (or more realistic).

Figure 1.1 Choice experiment question and Card example

Imagine taking the decision to purchase a new vehicle. Here are several options, A and B, for typical vehicles with different features that are currently sold in the automotive market. Please select the alternative car (car A, car B, neither A or B) you will buy. We present you several choices to select between various cars shown in each set.			
Characteristics	Conventional car	Hybrid car	Status quo
Price (€).	€16,000	€20,000	Neither A or B
Fuel consumption (€ per 100km).	€7/100km.	€5/100km.	
Grams of CO2 emitted per 1km.	150g/km.	100g/km.	
Biofuel adaptation	No	Yes	
I choose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1.3.2 CHOICE MODELING SPECIFICATION

Assuming utility maximizing behavior, the empirical applications based on discrete choice models make possible to estimate the probability that an individual chooses a given car alternative, among a set of available alternatives. The utility that an individual i derived from choosing a car alternative j among a set of J alternatives (conventional car, HEV or no-

choice option) in each choice situation t may be expressed (Hole, 2013; Train, 2009) as a sum of an observable utility component ($X'_{ijt}\beta$) and unobservable component or error term (ε_{ijt}):

$$U_{ijt} = X'_{ijt}\beta + \varepsilon_{ijt} \quad (1.1)$$

where,

X'_{ijt} : is a vector of specific car attributes and specific individual characteristics.

β : is a vector of parameters associated with the explanatory variables.

The multinomial logit model (MNL) (McFadden, 1974) is derived assuming that the error terms (ε_{ijt}) are independently and identically extreme value type I distributed (IID). The MNL probability of choosing an alternative a among a set of J alternatives is given by (Hole, 2013; Train, 2009):

$$L_{iat} = \frac{\exp(X'_{iat}\beta)}{\sum_{j=1}^J \exp(X'_{ijt}\beta)} \quad (1.2)$$

The MNL is based on the assumption of the independence of irrelevant alternatives (IIA). The MNL imposes homogeneity in tastes, inflexible substitution patterns in preferences between different alternatives and independence in unobserved factors over time (Train, 2003). An alternative model which is much more flexible and which overcomes the limitations of MNL is the RPL. In addition to the fact of not complying with the IIA property, the RPL allows for: a) random heterogeneous preferences across individuals, b) unrestricted substitution patterns, and c) correlation in unobserved factors over time (Train, 2003). The RPL model probability (unconditional probability) is the integral of the conditional probability over all the random parameters (Hole, 2013; Train, 2009):

$$P_{iat} = \int \frac{\exp(X'_{iat}\beta)}{\sum_{j=1}^J \exp(X'_{ijt}\beta)} f(\beta|\theta) d\beta \quad (1.3)$$

where,

$f(\beta|\theta)$: is the density function of the parameters β . This density function may be assumed to follow any closed-form distribution (normal, log-normal, triangular, uniform) (McFadden and Train, 2000; Train, 2003); θ : are the parameters (mean and standard deviation) of the distribution.

In this application, RPL models are estimated assuming log-normal distribution for the coefficients associated with price (PRICE), fuel consumption (FCONSUMPTION) and CO2 emissions (CO2) in order to force them to be negative (on one side of zero) for all individuals. In the same line as previous studies (Achtnicht, 2012; Daziano and Achtnicht, 2014; Nixon and Saphores, 2011), positive preferences for these attributes are not allowed, as it is not expected that people would prefer higher prices, higher fuel consumptions or higher CO2 emissions. Several distributions (normal, log-normal, uniform, triangular, etc.) are also tested for the coefficient associated with biofuel adaptation (BADAPTATION) but its standard deviation was not statistically significant. Thus, it is considered as a nonrandom parameter. This valuation exercise also aims to predict respondents choices between the two car-alternatives (conventional, and HEVs) and the no-car option (neither A or B), including in the DCE models two choice-specific constants, denoting the election of each particular car: ASC_c (for conventional cars), and ASC_h (for HEVs) which represent the car's type. It is assumed that both choice-specific constants follow a normal distribution because drivers may like or dislike each car-type. In addition, it explores how preferences for conventional or HEVs, compared to the no-car option, shift with the following socioeconomic variables: gender (MALE), age (AGE), and monthly income under €1,200 (LHINC). It also analyzes the heterogeneity in preferences for conventional or HEVs among drivers who reported that incentives such as direct subsidies (SUBSIDY), registration tax exemption (TAX), free parking (FPARKING), access to priority lanes (LANES), as well as other reputational factors such as a personal image (IMAGE) would be important factors when buying an efficient car. These incentive variables were created from the participants' ratings, when they were asked to state how important (on a 5-point Likert scale: from 1 "not important" to 5 "very important") these factors would be in their decision to select efficient cars.

Furthermore, and after the vector of parameters is obtained, the WTP welfare measures are calculated in order to determine the monetary equivalent of the marginal utilities placed by drivers in each car attribute improvement. This step may provide important information to policy makers regarding the economic efforts that people are willing to make to acquire HEVs and some improvements in car attributes.

In a MNL, WTP for an attribute is generally computed dividing the estimated marginal utility of that attribute (β_{Attr}) by the estimated marginal utility of price (β_{PRICE}) (Train, 2009), as shown by the following formulation:

$$WTP\{\text{Attribute"Attr"}\} = -\frac{\beta_{Attr}}{\beta_{PRICE}} \quad (1.4)$$

Given that in this case the utility function includes the car type-specific constants, it will be possible to compute the WTP for a HEV (h) compared to a conventional vehicle (c) as following:

$$WTP\{\text{HEV}\} = -\frac{1}{\beta_{PRICE}} [\beta_{ASC_h} - \beta_{ASC_c}] \quad (1.5)$$

where,

β_{ASC_h} and β_{ASC_c} : correspond to the estimated parameters associated with HEV (ASC_h) and conventional (ASC_c) car specific constants, respectively.

In a RPL model, when at least one of the parameters included in eq.(1.4) is estimated as a random parameter, the expression of the WTP ratio shown in eq.(1.4) becomes a randomly distributed term. In this case, with the exception of the WTP for biofuel adaptation which is log-normally distributed (the distribution of the parameter ratio is given by the distribution of the price parameter), the rest of the WTPs are ratio of two log-normal distributions. The ratios of two log-normal distributions as the case of the WTP for fuel consumption and CO2 emissions are also log-normal distributions. The fact that price is log-normally distributed ensures finite moments for the WTPs (Daly, et al., 2012). Hensher et al. (2015) proposed two

possible ways to construct the WTP measures, basing on conditional parameter estimates (individual moments) or unconditional parameter estimates (population moments). In the present application, WTP measures are constructed based on unconditional parameter estimates, because they allow for prediction outside of the sample, unlike conditional parameter estimates, which only predict within the sample (Jones and Hensher, 2004). Deriving WTP based on unconditional parameter estimates requires the population to be simulated (Hensher et al., 2015).

1.4 RESULTS AND DATA

Table 1.1 summarizes the drivers' perceptions towards HEVs (prior to the information received in the survey). When compared to conventional cars, 62% of the drivers perceived HEVs as being more expensive, although a further 28% stated that HEVs have low running costs. In addition, 14% believed that HEVs are slower, while 18% considered that HEVs have less power, and about 16% reported that they did not know what HEVs are like. Finally, 17% reported that HEVs have limited autonomy, showing a clear misunderstanding of the difference between HEVs and EVs.

Table 1.1 Perceptions for hybrid electric vehicles (HEVs)

Participants' hybrid car Perceptions	Mean	Std. Dev.
Compared to a conventional car,		
A hybrid car is more expensive	.620	.485
A hybrid car has lower running costs	.281	.449
A hybrid car is slower	.142	.349
A hybrid car has less autonomy	.168	.374
A hybrid car is less powerful	.176	.381
A hybrid car is less safe	.013	.116
I do not know what a hybrid car is	.158	.365

Table 1.2 describes the drivers' socio-demographic characteristics and the variables included in the empirical models, containing basic information about the rated importance of incentives including direct subsidies, registration tax exemption, free parking, access to priority lanes, and social image. In summary, public policies based on direct economic incentives, such as subsidies or allowing free parking are perceived as the most important incentives for drivers to buy an efficient car, followed by access to priority lanes and registration tax exemption. Social image is the least relevant factor for the drivers in buying an efficient (newer) car.

In terms of socio-demographics, the average age of participants in this sample is 46 years, and 51% of the participants were male. One fifth of the participants were unemployed, and about 25% of all households received a monthly income of less than €1,200. The participants reported that on average they drive a car 4 days a week. The sample was representative of the profile of a Spanish driver at least with respect to some important characteristics, such as age and driving frequency. The Spanish Observatory of Drivers (2014) defined, through a representative study, a typical Spanish driver as being a 44-year-old male, who uses a car an average of 5 days a week for work.

Table 1.2 Descriptive statistics of the variables included in the RPL model

Variable	Description	Mean	Std. Dev.
PRICE (Continuous)	purchase price of car-option divided by 10,000.	1.066	.805
FCONSUMPTION (Continuous)	euros spent in fuel consumption per 100km.	4	2.943
CO2 (Continuous)	grams of CO2 emitted per 1km.	83.333	62.362
BADAPTATION (Dummy)	1 if car-option is adaptable (flex-fuel) to run with biofuels and 0 otherwise.	.333	.471
ASC _c (Dummy)	Conventional car-specific constant.	.333	.471
ASC _h (Dummy)	HEV-specific constant.	.333	.471
MALE (Dummy)	1 for male and 0 otherwise.	.513	.499
AGE (Continuous)	age of participants (years).	45.972	13.546
LHINC (Dummy)	1 for monthly income under €1,200 and 0 otherwise.	.246	.431
SUBSDY (Continuous)	importance (score) attributed to the incentive "direct subsidies".	4.199	.961
TAX (Continuous)	importance (score) attributed to the incentive "registration tax exemption".	3.552	1.204
FPARKING (Continuous)	importance (score) attributed to the incentive "free parking".	4.198	.915
LANES (Continuous)	importance (score) attributed to the incentive "access to priority lanes".	3.928	1.165
IMAGE (Continuous)	importance (score) attributed to the incentive "social image".	2.744	1.256

Table 1.3 summarizes the results of the estimated models. First, a MNL model is estimated and the assumption of independent irrelevant alternatives (IIA) is tested using the Chi-squared Hausman and McFadden test. The results of this test reject the IIA assumption [being the omitted alternative the regular car: Chi-squared (5) = 156.808; with the omitted alternative being the HEV: Chi-squared (5) = 160.883; the 99%; critical value: Chi-squared (5) = 15,086]. Then, to improve the performance, RPL models have been estimated, allowing for

correlation over time (but with uncorrelated parameters) and using NLOGIT.5 software with 2000 replication draws in the estimation processes. In particular, a baseline RPL and a RPL model with heterogeneity in the mean of the random parameters associated with the choice specific constants are specified.

In Table 1.3, Column 1 shows the results of the MNL; the RPL results are presented respectively in Column 2 (baseline RPL), and Column 3 (extended RPL, with interaction terms with the constants). According to the values of the log-likelihood, adjusted pseudo-R², Akaike information criterion (AIC), the RPL improves the MNL model fit (which results are not directly discussed). The moments of the coefficients associated with PRICE, FCONSUMPTION, and CO2 which are calculated converting the log terms¹ are presented in this table.

The results of the baseline RPL model show that the mean of both nonrandom and random parameters are significant and have the expected signs. The results are similar to those provided by the MNL model. In line with previous findings (Adler et al., 2003), the two monetary attributes that were included –price (PRICE) and fuel consumption (FCONSUMPTION)– have negative effects on utility, indicating that drivers tend to prefer cars with a lower price and lower fuel consumption. This implies that one of the motives that may attract drivers to adopt HEVs is fuel economy. Similarly, and in agreement with findings from previous studies (Potoglou and Kanaroglou, 2007), the coefficient associated with CO2 emissions (CO2) is negative, implying that on average, drivers prefer cars with lower levels of CO2 emissions. Furthermore, the fact that the car could be adapted to biofuels (BADAPTATION) carries a positive effect on utility, implying that drivers prefer flexible-

¹ Note that the sign of the variables PRICE, FCONSUMPTION, and CO2 have been inverted and entered as negative in the RPL model specifications (Hensher et al., 2015). The log-normally distributed coefficients are expressed as: $\beta_k = \exp(b_k + s_k \mu_k)$ where, μ_k is IID standard normal deviate, b_k and s_k are the estimated mean and standard deviation for log-normally distributed coefficient. The table above presents the moments of the coefficients associated with PRICE, FCONSUMPTION, and CO2 which are calculated in the following way (Revelt and Train, 1998; Shimizu and Crow, 1988): $Mean = \exp(b_k + (s_k^2 / 2))$; $Standard\ deviation = mean * \sqrt{(\exp(s_k^2) - 1)}$. Note that the mean of PRICE, FCONSUMPTION, and CO2 were multiplied by -1 in order to reestablish the sign changed a priori to the model estimation (Hole, 2007).

fuel cars to non-adapted cars. Regarding the standard deviations, it is found that the three random parameters (PRICE, FCONSUMPTION, and CO2) have statistically significant standard deviations, implying that there are heterogeneous preferences for these attributes across drivers. However, while the standard deviation of ASC_c is statistically significant at any critical level, that of HEVs (ASC_h) is not statistically significant. This may reveal some limitations in the current model in order to control for the potential wide heterogeneity of preferences towards HEVs, which it is aimed to control for considering the next extended RPL model.

The next RPL model explores whether the shift in the mean of the choice-specific constants due to drivers' socio-demographic characteristics (MALE, AGE and LHINC) and drivers' preferences towards the incentives (SUBSIDY, TAX, FPARKING, LANES and IMAGE) when buying efficient cars, improves the fit of the baseline RPL. Contrary to the baseline RPL, the standard deviation of the HEV specific constant is statistically significant, showing heterogeneity in tastes for HEVs. The results also show that MALE are more likely to choose an efficient car in terms of consumption (HEV or a conventional car) over the status quo no-car option in the DCE, whereas depending on the drivers' age (AGE), there is no significant heterogeneity in preferences for conventional or HEVs compared to the no-car option. Drivers with monthly income under €1,200 do not show any significant preferences toward HEVs or conventional cars with respect to the no-car option. Interaction terms between the conventional car specific constant and the preferences towards monetary and non-monetary incentives are not statistically significant, while all the interaction terms between these preferences for incentives (except SUBSIDY) and the HEV specific constant are statistically significant. The positive interaction term $ASC_h * FPARKING$, indicates that the more important free parking (FPARKING) is for drivers, the more likely they are to enter the market of HEVs compared to the no-car status quo option. Social prestige (IMAGE) also has a positive effect on the mean utility of selecting HEV. In terms of TAX, we find that individuals who stated that tax breaks are more important for them when buying a new car are less likely to buy HEVs. These may be caused by the fact that drivers who are more sensitive to tax rebates are also more sensitive to price in general, and as a consequence, they are not willing to enter the HEV market, which is more expensive. A surprising result is derived from the drivers who stated that when buying a new car, access to priority lanes is important. In

fact, this segment of buyers is less likely to buy HEVs. This result may be due to the fact that priority lanes for HEVs are not as common as free parking; and in practice, in many cities priority lanes are only accessible to EVs.

Table 1.3 Results of estimated MNL and RPL models

Parameters in utility functions	MNL			Baseline RPL			RPL		
	Coeff.	Std. Error	Prob. |z| > Z	Coeff.	Std. Error	Prob. |z| > Z	Coeff.	Std. Error	Prob. |z| > Z
PRICE	-2.056	.055	.000	-3.085	.085	.000	-2.716	.067	.000
FCONSUMPTION	-.281	.017	.000	-.462	.027	.000	-.470	.038	.000
CO2	-.010	.001	.000	-.021	.003	.000	-.014	.001	.000
BADAPTATION	.200	.034	.000	.257	.042	.000	.249	.044	.000
ASC _c	5.844	.178	.000	9.928	.248	.000	9.057	.466	.000
ASC _h	6.267	.181	.000	10.571	.251	.000	9.570	.450	.000
Standard deviations of random parameters									
LSPRICE	.	.	.	1.209	.106	.000	.680	.056	.000
LSFCONSUMPTION	.	.	.	.339	.058	.000	.346	.055	.000
LSCO2	.	.	.	.025	.007	.000	.009	.001	.000
NSASC _c	.	.	.	1.145	.086	.000	.890	.062	.000
NSASC _h	.	.	.	.205	.446	.645	.357	.129	.006
Heterogeneity in mean, Parameter * Variable									
ASC _c * MALE	.	.	.	.	.	.	.601	.167	.000
ASC _c * AGE	.	.	.	.	.	.	-.007	.006	.232
ASC _c * LHINC	.	.	.	.	.	.	.175	.187	.349
ASC _c * SUBSDY	.	.	.	.	.	.	-.137	.092	.139
ASC _c * TAX	.	.	.	.	.	.	.029	.079	.706
ASC _c * FPARKING	.	.	.	.	.	.	.091	.074	.222
ASC _c * IMAGE	.	.	.	.	.	.	.083	.063	.190
ASC _c * LANES	.	.	.	.	.	.	-.097	.065	.138
ASC _h * MALE	.	.	.	.	.	.	.521	.162	.001
ASC _h * AGE	.	.	.	.	.	.	-.002	.005	.717
ASC _h * LHINC	.	.	.	.	.	.	.038	.186	.837
ASC _h * SUBSDY	.	.	.	.	.	.	-.047	.085	.576
ASC _h * TAX	.	.	.	.	.	.	-.135	.076	.076
ASC _h * FPARKING	.	.	.	.	.	.	.202	.070	.004
ASC _h * IMAGE	.	.	.	.	.	.	.119	.061	.050
ASC _h * LANES	.	.	.	.	.	.	-.171	.064	.008
Measures of goodness of fit									
N	7,000			7,000			7,000		
GROUPS	875			875			875		
NB. OBS./GROUP	8			8			8		
L.L. FUNCTION	-6,578.012			-5,287.501			-4,917.870		
K	6			11			27		
CHI SQUARED [K]	.			4,805.568			4,019.956		
SIGNIFICANCE	.			.000			.000		
R-SQUARED	.136			.312			.290		
ADJ. R-SQUARED	.135			.311			.288		
AIC	13,168.0			10,597.0			9,889.7		

- N: Number of observations; K: Number of factors; L.L.: Log-likelihood; AIC: Akaike information criterion.

Table 1.4 shows the mean WTPs for the car attributes estimated from each of the three empirical models. While column 1 of Table 1.4 shows the WTPs estimated from the MNL model, column 2 and column 3 represent the WTPs calculated from the baseline RPL and the RPL (with heterogeneity in the mean of choice specific constants) models, respectively. In the baseline RPL, the drivers' WTP for a car, which achieves a reduction in fuel expenses of €1/100km., is €1,925.882. In addition, drivers' WTP for a car, which achieves a reduction in CO₂ emissions of 1g/km., is €81.417. Furthermore, the mean drivers' WTP for a car to be adaptable to biofuels is €942.418. Finally, drivers are not, *ceteris paribus*, willing to pay a statistically significant premium to move from a conventional to a HEV. Therefore, participants are willing to make an economic effort to buy a vehicle with low fuel consumption, low CO₂ emissions and a vehicle adapted to run with biofuels but they do not want to do it just for being a HEV. In the extended RPL with heterogeneity in choice specific constants, when the WTP for HEV is simulated, it is found that drivers are not, *ceteris paribus*, likely to pay an extra to switch from a conventional to a HEV; however, they are ready to pay for improvements in vehicle attributes. Once again, the results reiterate the need of informational mechanisms as to ensure the understanding of HEVs attributes. This is in fact nowadays an obstacle to increasing the market share of hybrid technology.

Table 1.4 Mean WTP estimates

Attribute/Alternative	MNL	BASELINE RPL	RPL
	Mean	Mean	Mean
€1 saving in fuel consumption per 100km. (FCONSUMPTION)	€1,368.78*** (€86.243)	€1,925.882** [€899.999]	€2,104.816*** [€665.952]
1g abated in CO ₂ emissions per 1km. (CO ₂)	€49.618*** (€3.395)	€81.417** [€40.402]	€65.860*** [€19.836]
to be adapted to run with biofuel adaptation (BADAPTATION)	€973.045*** (€166.487)	€942.418*** [€375.042]	€979.750*** [€244.231]
hybrid electric vehicle (HEV)	€2,052.49*** (€170.299)	€625.433 [€1,324.805]	€719.961 [€1,139.100]

- ***, **, *: Significance at 1%, 5%, 10% level; (): Standard Error; []: Standard deviation.

1.5 CONCLUSIONS AND IMPLICATIONS

A DCE included in a structured online survey is conducted in order to identify the most important attributes that affect car choice decisions. In particular, it assesses whether improvements in fuel consumption and CO₂ emissions would encourage drivers to buy HEVs.

The present research explores the importance of monetary and non-monetary incentives, generally adopted by governments to boost sales of fuel-efficient cars. It tests whether drivers who consider these incentives to be important are especially attracted to HEVs. The participants in a national survey were asked to rate the importance that some public policies would have in their decision to switch to efficient cars (HEVs or new medium cars). They rated policies based on reductions in direct subsidies or allowing free parking to be the most important incentives, followed by access to priority lanes and registration tax exemption, and finally by the social image derived from driving an efficient car.

Nearly half of the sample perceives HEVs to be cleaner than gasoline, diesel, biofuels, and liquefied petroleum gas (LPG) cars. Three out of ten drivers believe that HEVs have lower running costs than conventional cars. However, many drivers (62%) perceive them to be more expensive, slower, and less powerful than conventional cars (18%). In addition, some drivers do not exactly know what HEVs are (15%), or clearly misunderstand the difference between HEVs and EVs (16%).

The estimated stated preference RPL models show that drivers prefer cheaper cars with low fuel consumption, implying that fuel economy may be an attractive reason to buy HEVs. Similarly, low CO₂ emissions increase the utility derived from a car, and are another reason to encourage drivers to buy HEVs. The subjects also expressed strong preferences for flexible-fuel cars, concluding that offering HEVs adapted to run with biofuels could increase the demand for HEVs.

The results derived from the extended RPL model show that drivers are not, *ceteris paribus*, willing to pay an extra premium to change from conventional automobiles to HEVs; however they are willing to pay more for a vehicle with low fuel consumption, low environment impacts and a vehicle adapted to run with biofuels. Therefore, given that drivers do not associate improvements in attributes with HEVs, the current offered subsidy (€1,500 from the *Pive* plan) does not cover the price margin between a conventional model and HEVs available on the market. Moreover, the results show that when controlling for socio-demographic characteristics, drivers who state that free parking policies and social image are important are more likely to buy HEVs.

To conclude, and as earlier stated, a segment of drivers fail to distinguish between HEVs and EVs, so designing information campaigns that provide accurate information on HEVs may have a significant impact on sales. Therefore, information campaigns directed by dealers and supported by the public authorities may be useful to promote the use of HEVs and encourage these environmentally sustainable transport alternatives. Another potential remedy is to promote the use of HEVs for taxis and public transport, and to encourage the public authorities to replace their conventional cars with HEVs. This may help to further promote the image of HEVs, drivers' knowledge about them, and to reduce the current distrust towards this alternative fuel technology. This set of findings may be relevant in order to adopt appropriate and effective strategies in the future aimed at reducing road transport, greenhouse gas emissions, and their contribution to climate change.



1.6 REFERENCES

Achtnicht, M., 2012. German car buyers' willingness to pay to reduce CO2 emissions. *Climatic Change* 113(3-4), 679-697.

Adler, T., Wargelin, L., Kostyniuk, L., Kavalec, C., Occhiuzzo, G., 2003. Incentives for alternative Fuel Vehicles: A Large-Scale Stated Preference Experiment, paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, August 10-15, 2003.

Asociación española de fabricantes de automóviles y camiones (ANFAC), 2014. <http://www.anfac.com/estadisticas.action> (accessed 25.01.16).

Asociación Española de Fabricantes de Automóviles y Camiones (ANFAC), 2017. http://www.anfac.com/estadisticas.action?accion=estad_turismos (accessed 12.01.17).

Axsen, J., Mountain, D.C., Jaccard, M., 2009. Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles. *Resource and Energy Economics* 31(3), 221–238.

Caulfield, B., Farrell, S., McMahon, B., 2010. Examining individuals' preferences for hybrid electric and alternatively fuelled vehicles. *Transport Policy* 17 (6), 381–387.

Chua, W.Y., Lee, A., Sadeque, S., 2010. Why do people buy hybrid cars?, in *Proceedings of Social Marketing Forum*, University of Western Australia, Perth, Western Australia, Edith Cowan University, Churchlands, W.A., 1-13.

Daly, A., Hess, S., Train, K., 2012. Assuring finite moments for willingness to pay in random coefficient models. *Transportation* 39, 19-31.

Daziano, R.A., Achtnicht, M., 2014. Accounting for uncertainty in willingness to pay for environmental benefits. *Energy Economics* 44, 166–177.

Directive 2009/30/EC of the European Parliament and of the Council amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC. Official Journal of the European Union 5.6.2009.

Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels or other renewable fuels for transport. Official Journal of the European Union 17.05.2003 P.

Directive 2009/33/EC of the European Parliament and of the Council on the promotion of clean and energy-efficient road transport vehicles. Official Journal of the European Union 5.15.2009.

Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Official Journal of the European Union 5.6.2009.

Ecologists in Action, 2011. La calidad del aire en el Estado español. EIA Report 2011. https://www.ecologistasenaccion.org/IMG/pdf/informe_calidad_aire_2011.pdf (accessed 12.07.16).

Erdem, C., Sentürk, I., Simsek, T., 2010. Identifying the factors affecting the willingness to pay for fuel-efficient vehicles in Turkey: A case of hybrids. Energy Policy 38 (6), 3038–3043.

European Commission, 2015. 2030 climate and energy framework. http://ec.europa.eu/clima/policies/strategies/2030/index_en.htm (accessed 12.07.16).

European Commission, 2013. Commission Staff Working Document Accompanying the Communication on a revised EU Strategy on Air Pollution Proposal for a revision of Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants. Proposal for a legislative instrument on control of emissions from Medium Combustion Plants

-Impact Assessment, SWD 531, European Commission, Brussels.
http://ec.europa.eu/environment/archives/air/pdf/Impact_assessment_en.pdf (accessed 12.07.16).

European Commission, 2012. Road transport: Reducing CO2 emissions from vehicles.
http://ec.europa.eu/clima/policies/transport/vehicles/index_en.htm (accessed 12.07.16).

Ewing, G., Sarigöllü, E., 1998. Car fuel-type choice under travel demand management and economic incentives. *Transport Research D* 3 (6), 429–444.

Granovskii, M., Dincer, I., Rosen, M.A., 2006. Economic and environmental comparison of conventional, hybrid, electric and hydrogen fuel cell vehicles. *Journal of Power Sources* 159, 1186–1193.

Hackbarth, A., Madlener, R., 2016. Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany. *Transportation Research Part A: Policy and Practice* 85, 89–111.

Hall, J., Viney, R., Haas, M., Louviere, J., 2004. Using stated preference discrete choice modelling to evaluate health care programs. *Journal Business Research* 57, 1026-32.

Heffner, R.R., Kurani, K.S., Turrentine, T.S., 2007. Symbolism in California's early market for hybrid electric vehicles. *Transportation Research Part D: Transport and Environment* 12 (6), 396-413.

Hensher, D.A., Rose, J.M., Greene, W.H., 2015. *Applied choice analysis*. Second edition, Cambridge University Press.

Hidrue, M.K., Parsons, G.R., Kempton, W., Gardner, M.P., 2011. Willingness to pay for electric vehicles and their attributes. *Resource and Energy Economics* 33 (3), 686–705.

Hole, A.R., 2007. Fitting mixed logit models by using maximum simulated likelihood. *The Stata Journal* 7, 388-401.

Hole, A.R., 2013. Mixed logit modelling in stata: An overview. UK stata users group meeting September 2013.

Instituto para la diversificación y ahorro de la energía (IDAE), 2015. Real Decreto 124/2015: programa de incentivos al vehículo eficiente (*PIVE-7*). <http://www.idae.es/index.php/relcategoria.4030/id.838/relmenu.441/mod.pags/mem.detalle> (accessed 12.07.16).

Jabeen, F., 2011. Electric Vehicle Acceptance: A Household Study. 2011 International Conference on Petroleum and Sustainable Development IPCBEE vol. 26 IACSIT Press, Singapore.

Johnson, R.M., Orme, B.K., 1996. How many questions should you ask in choice-based conjoint studies? Sequim, WA: Sawtooth Software.

Jones, S., Hensher, D.A., 2004. Predicting financial distress: a mixed logit model. *Accounting review* 79(4), 1011-1038.

Lancaster K., 1966. A new approach to consumer theory. *The Journal of Political Economy* 74, 132-57.

Law 34/2007, 15 November, on Air Quality and Protection of the Atmosphere. BOE number. 275.

Louviere, J.J., Flynn, T.N., Carson, R.T., 2010. Discrete choice experiments are not conjoint analysis. *Journal of Choice Modelling* 3(3), 57-72.

McFadden, D., 1974. Conditional logit analysis of qualitative choice behavior. In *Frontiers in Econometrics*, ed. P. Zarembka, New York: Academic Press, 105-42.

McFadden, D., Train, K., 2000. Mixed MNL Models for Discrete Response. *Journal of Applied Econometrics* 15(5), 447-470.

Nixon, H., Saphores, J.D., 2011. Understanding household preferences for alternatives-fuel vehicle technologies. Report 10-11, Mineta Transportation Institute, San José, CA, 2011.

Potoglou, D., Kanaroglou, P.S., 2007. Household demand and willingness to pay for clean vehicles. *Transportation Research Part D* 12(4), 264-274.

Qian, L., Soopramanien, D., 2011. Heterogeneous consumer preferences for alternative fuel cars in China. *Transportation Research Part D* 16, 607–613.

Revelt, D., Train, K., 1998. Mixed logit with repeated choices: households' choices of appliance efficiency level. *Review of Economics and Statistics* 80, 1-11.

Royal Decree 61/2006, 31 January, on the determination of specifications for petrol, diesel, fuel oil and liquefied petroleum gas and the use of certain biofuels is regulated. BOE-A-2006-2779.

Shimizu, K., Crow, E.L., 1988. Lognormal distributions: Theory and applications. New York: Dekker.

Spanish Observatory of Drivers, 2014. Estudio del conductor español: hábitos en los desplazamientos y viajes en vacaciones. <http://www.ducit.es/estudios-ducit> (accessed 10.06.15).

Street, D.J., Burgess, L., and Louviere, J.J., 2005. Quick and Easy Choice Sets: Constructing Optimal and Nearly Optimal Stated Choice Experiments. *International Journal of Research in Marketing* 22, 459-470.

Street, D., Burgess, L., 2007. The construction of optimal stated choice experiments. New Jersey: John Wiley and Sons Inc. <http://crsu.science.uts.edu.au/choice/choice.html> (accessed 08.04.12).

Thatchenkery, S.M., Beresteanu, A., 2008. Determinants of Automobile Demand and Implications for Hybrid-Electric Market Penetration. Honors thesis submitted in partial fulfilment of the requirements for Graduation with Distinction in Economics in Trinity College of Duke University.

Toyota, 2016. <http://www.toyota.es/coches/yaris/index.json> (accessed 18.01.2016).

Train, K., 2003. Discrete Choice Methods with Simulation. Cambridge University Press.

Train, Kenneth E., 2009. Discrete Choice Models with Simulation. New York: Cambridge University Press (2), 77-82.

Wu, L., Li, C., Qian, H., Zhang, Z., 2013. Understanding the Consumption Behaviors on Electric Vehicles in China - A Stated Preference Analysis. Fondazione Eni Enrico Mattei Working Papers. Paper 832.

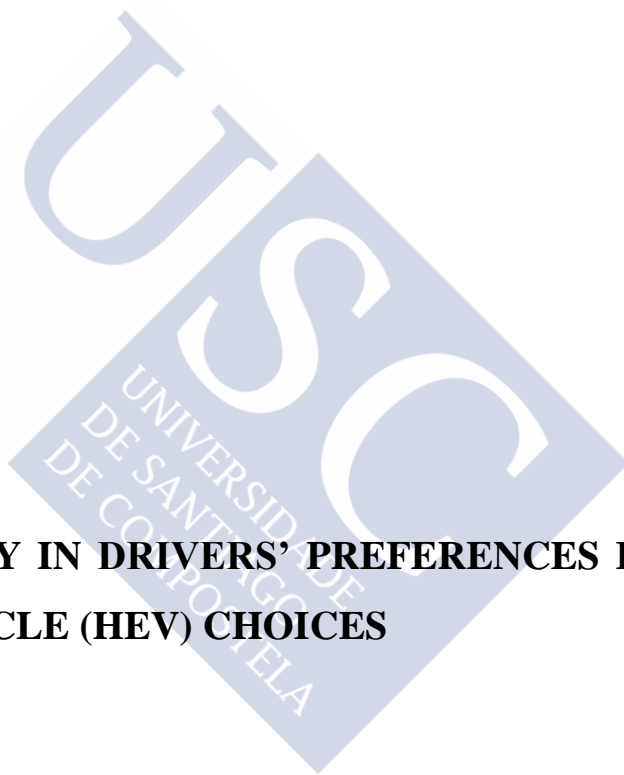
Zhang, Y., Yu, Y., Zou, B., 2011. Analyzing public awareness and acceptance of alternative fuel vehicles in China: The case of EV. Energy Policy 39 (11), 7015–7024.

Ziegler, A., 2012. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. Transportation Research Part A: Policy and Practice 46 (8), 1372-1385.



CHAPTER 2

HETEROGENEITY IN DRIVERS' PREFERENCES FOR HYBRID ELECTRIC VEHICLE (HEV) CHOICES





2. HETEROGENEITY IN DRIVERS' PREFERENCES FOR HYBRID ELECTRIC VEHICLE (HEV) CHOICES

Abstract

To analyze heterogeneity in drivers' preferences for hybrid electric vehicles (HEVs), a discrete choice experiment (DCE) is conducted in a representative sample of Spanish drivers. Our results identify 4 groups of drivers ("enthusiastic for HEV but mainly due to aspirational aspects," "skeptical HEV buyers," "HEV-oriented and conscious drivers," and "good deal seekers") whose preferences are different between each other. The heterogeneity across groups was manifested by the relative importance given to the different vehicle attributes, and the number and order of these attributes that affect vehicle choices. Furthermore, even though the driver sample is willing to pay an average premium of only €2,476.75 to change from a conventional vehicle to a HEV, *ceteris paribus*, participants are willing to pay important amounts for improvements in energy or environmental efficiency and for the car to be adapted to biofuels. In particular, our findings show that the market share for HEVs is promising as long as information strategies are articulated. Other findings may serve as a guide to design accurate strategies for promoting sustainable transportation technologies and address them to the right target population.

2.1 INTRODUCTION

Global warming and air pollution are global problems caused by increased world's total greenhouse gases and pollutants emissions. The degradation of air quality has harmful implications for human health and well-being, biodiversity, and the environment. Although it is a global problem requiring international solutions, it also needs local initiatives adapted to the specific sectorial characteristics of each country and pollution problems (European Environment Agency, 2008).

In Spain, in addition to industries and manufacturing activities, transport (particularly road transport) is one of the largest sources of air pollution. The transport sector emits 23.7% [with an average for the European Union (EU) of 20%] of the total greenhouse gas (GHG) generated in Spain in 2012 (OTLE, 2015), while road transport is responsible for 92.3% (70.3% by passenger transport and 22% by good transport) of the total transport sector emissions. In particular, private road transport is the main responsible source of the high levels of pollution in urban areas. In 2014, a WHO study (WHO, 2014) revealed that from a total of 46 Spanish cities, only 9 meet WHO 2005 recommended pollution levels (WHO, 2005). To reflect the seriousness of this situation, a total 67 exceedances of the hourly limit value of nitrogen dioxide (200 micrograms of No₂ per 1 m³ of air) have been recorded in Madrid in 2015 (Ecologists in Action, 2015).

In spite of the seriousness of pollution, the market share of environmentally friendly vehicles or alternative fuel vehicles (AFVs)² in Spain is still very small. While electric vehicles (EVs) seem more long-term alternatives, hybrid electric vehicles (HEVs)³ may be the option for the short and medium-term since they are the most similar to conventional vehicles. In 2016, only 2.70% of the 1,147,007 passenger vehicles sold in Spain were hybrid vehicles [HEVs and plug-in hybrid electric vehicles (PHEVs)⁴] while the absolute majority were HEVs. The Japanese Toyota Lexus group continues to lead the hybrid vehicle sales in Spain (ANFAC, 2017). This brand sells its HEV models at prices between €3,000 to €5,000 above its corresponding conventional models (Toyota, 2016).

² Alternative fuel vehicles (AFVs) use fuels different to traditional ones (gasoline or diesel), or combine traditional with electric engines. They refer to biofuel vehicles, natural gas vehicles, hydrogen vehicles, electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) (Hackbarth and Madlener, 2013).

³ Hybrid electric vehicles (HEVs) refer to vehicles (Toyota Prius, Toyota Yaris) which combine internal combustion engines (gasoline or Diesel) and electric engines to run. They generate electricity from their internal combustion engines and use it to recharge their batteries (Hadley and Tsvetkova, 2009).

⁴ The plug-in hybrid electric vehicles (PHEVs) are hybrid electric vehicles (HEVs) with rechargeable lithium-ion batteries which may be recharged by connecting it to an external electric plug (Hadley and Tsvetkova, 2009).

Mixed earlier findings concerning the potential of AFVs to gain market share in the future, made necessary to conduct a study where preferences towards environmental and economic vehicle attributes are assessed simultaneously. In this research paper, a discrete choice experiment (DCE) approach was used to assess drivers' preferences towards vehicle type and attributes. In addition of being much recommended for welfare measures (Louviere et al., 2010), the DCE allows to disaggregate the individual's welfare assigned to a given vehicle into marginal utilities (and corresponding marginal valuations) corresponding to each one of the different attributes. Most related studies about hybrid vehicles (HEVs or PHEVs) were carried out in North America (Hidrué et al., 2011; Kahn, 2007; Klein, 2007; Lin et al., 2012; Partridge, 2013; Thatchenkery and Beresteanu, 2008), or in Australia (Abdoolakhan, 2010; Beck et al., 2013; Chua et al., 2010). The penetration rate of these technologies in North America and Australia is significantly higher than in Europe (Achnicht, 2012; Hackbarth and Madlener, 2013; Hackbarth and Madlener, 2016; Ziegler, 2012). The general interest of the present work is to identify the most important factors that drive preferences for specific attributes and type of vehicles, especially HEVs. Undoubtedly, preference heterogeneity has been very little explored in the context of AFV choices. To capture driver's preference heterogeneity, a latent class model (LCM) was specified, relaxing the imposed homogeneity preference assumed by the multinomial logit model (MNL). The LCM analyzes and segments the sample on a set of different groups of drivers, building the classes on the driver heterogeneities in the assessment of the attributes. In addition to identify the determinant factors affecting vehicle choices, the profile of the drivers included in each latent group was defined by introducing a set of covariates (driver specific characteristics) in the model specification. This latent segmentation will allow determining the amount, the sources, and the role of several types of heterogeneity associated with vehicle choice decisions across driver' groups. This approach will allow obtaining more accurate results which would improve our predictions in terms of drivers' preferences while helping to design better possible promotion strategies. The present research provides new, innovative and promising results contributing to improve the understanding of vehicle choice process. They emphasize that, in general, drivers have different preferences when buying vehicles. Significant preference heterogeneity about automobiles is found, particularly in the magnitude of the attribute effects, number and the importance order of the attributes that drive vehicle choice decisions. In particular, drivers who buy HEVs do not always do it for environmental motives

but also for reputational issues. Moreover, drivers not interested in HEVs are not automatically environmentally unconscious, because their choice may be motivated by other reasons, or may be due to mistrust or misconceptions about this technology. Although conventional vehicles still dominate the market, HEVs and flexible-fuel vehicles (FFV) are able to increase their market share in the future at least among certain segments.

2.2 LITERATURE REVIEW

There is an extensive literature concerning the adoption of AFVs; however, a limited amount of studies assesses preferences for HEVs specifically. Within the studies that deal with preferences for hybrid vehicles (HEVs or PHEVs), diverse explanatory variables have been used in the specification of the vehicle choice model, starting from vehicle specific attributes (Thatchenkery and Beresteanu, 2008) to external factors, including individual specific profiles (Erdem et al., 2010; Liu, 2014; Thatchenkery and Beresteanu, 2008), individual vehicle usage behavior (Lin et al., 2012), individual environmental attitudes (Kahn, 2007; Thatchenkery and Beresteanu, 2008), and individual social status (Chua et al., 2010; Partridge, 2013). In general, findings suggest that greater fuel efficiency (Thatchenkery and Beresteanu, 2008), higher educational level, higher income level, higher environmental awareness (Erdem et al., 2010; Liu, 2014; Thatchenkery and Beresteanu, 2008) and social status-seeking (Chua et al., 2010) motivate individual preferences for hybrid vehicles. In a recent study, Partridge (2013) showed the positive impact of the HEV on the individual welfare. However, this gain of utility in part is attributed to individual preferences towards seeking social image (Chua et al., 2010; Partridge, 2013). Previously, Klein (2007) showed that less than 3 of each 10 Prius hybrid vehicle buyers in the US during 2006 bought them because of environmental reasons. He reported that the rest selected this vehicle because of financial motivations.

There exist few studies (Abdoolakhan, 2010; Beck et al., 2013; Hackbarth and Madlener, 2016; Hidrue et al., 2011) which used LCM to assess preferences for AFVs. Abdoolakhan (2010) used a DCE to elicit Australian resident preferences for petrol, diesel, different biofuel, different liquefied petroleum gas, and HEVs. They constructed the DCE using some vehicle attributes, including cost attributes (Purchase price, weekly fuel cost, maintenance cost), and

others related to comfort (fuel availability, vehicle size and number of doors, condition of vehicle, type of transmission, and additional LPG tank). A latent class analysis (LCA) identified two different segments within the considered population, including one more sensitive group towards fuel efficiency and manual transmission (with respect to a second one). In a stated preference experiment, Beck et al. (2013) assessed Australians' preferences for diesel, petrol and hybrid vehicles. A latent class analysis (LCA) revealed the presence of four different segments across the target population, including "diesel drivers", "captive cynics", "car lovers", and "green vehicle friendly" groups. They reported that, regarding emissions charge, both "diesel drivers" and "captive cynics" were sensitive to either the annual and variable charge although the last ones were much more affected. Hackbarth and Madlener (2016) examined German preferences for different AFVs using DCE. They found that people' preferences for AFVs were heterogeneous across 6 different groups. Only two groups showed strong preferences in favor of AFVs; in particular, the group named "AFV aficionados" and the "PHEV enthusiasts." Hidrue et al. (2011) conducted a DCE to analyze US residents' preferences for EVs compared to their preferred gasoline vehicles, identifying via a latent class model two preference classes, including the "EV oriented" and the "gasoline vehicle oriented" groups.

The present research contributes to the literature on drivers' preferences heterogeneity through the use of a LCM that allows explaining why groups of similar drivers make different choices. This research explores the heterogeneity of drivers' preferences for improvements in specific vehicle attributes and checks whether these differences are translated into different efforts that different driver' groups are willing to make in order to acquire these improvements. It identifies heterogeneity in preferences for vehicle specific attributes among driver' groups and explains the part due to determinants such as sociodemographic characteristics and reputational incentives. Moreover, the present valuation assess whether HEVs are statistically preferred to conventional vehicles, in *ceteris paribus* conditions, within each driver group. It also estimates the premium that different driver' groups are willing to pay for HEVs and compares them to the existing public subsidies under the current market conditions. Overall, the present empirical exercise allows identifying the pro-HEV driver groups and those who are not, but also enables to distinguish between those who prefer a HEV for environmental reasons or for reputational reasons.

2.3 METHODS

2.3.1 DCE

DCEs are widely used to elicit individual preferences for AFVs (Ewing and Sarigöllü, 2000; Hackbarth and Madlener, 2013; Hackbarth and Madlener, 2016; Hoen and Koetse, 2012; Tanaka et al., 2014). In a DCE, individuals face a sequence of choices where they are asked to choose their preferred alternative in each choice set. The set of options includes a limited number of different alternatives (Hensher et al., 2015; Train 1993). In addition, given that the alternatives are defined by the same attributes but with different levels, when individuals are making a tradeoff between different alternatives they are also doing it between different attributes (importance ranking) and different attribute levels.

Focusing on the existing literature (Potoglou and Kanaroglou, 2007), a total of five relevant vehicle attributes were included in the DCE, including vehicle type, price, fuel consumption, CO₂ emissions and biofuels adaptation. Because the preferences that drivers assign to HEVs vs. regular vehicles are of interest for this research, the attribute vehicle type was selected with two possible levels (conventional and HEV). Given that the aim was to assess the heterogeneity of drivers' willingness to pay (WTP) for vehicle attributes, the attribute price which is crucial when purchasing a vehicle was selected (Adler et al., 2003). In order to use realistic values for price, price information from the Spanish market for small and midsize vehicles was used to define three possible levels of the attribute price: a low level (€12,000), an intermediate level (€16,000) and a high level (€20,000). The intermediate level corresponds to the average price of passenger cars sold in Spain in 2012. The upper and lower limits have been established taking into account the fact that HEVs are offered at prices between €3,000- €5,000 above than their conventional models, and the fact that most of the passenger vehicles sold in Spain in the last years cost less than €20,000.

In addition of being an important vehicle characteristic for drivers (Adler et al., 2003), and because the aim was to assess drivers' preferences for fuel efficiency improvements in vehicles, the attribute fuel consumption was added with two suitable levels: an efficient level

(€5 per 100 kilometers) and a more inefficient level (€7 per 100 kilometers). The values were displayed in euros per 100 kilometers to make easy the tradeoff between attributes (Achtnicht, 2012; Ziegler, 2012).

In addition, two environmental attributes have been included in the choice. In particular, carbon dioxide (CO₂) emissions, and the option of biofuel adaptation. Similarly, focusing on small/midsize vehicles and recent studies (Achtnicht, 2012; Ziegler, 2012), two possible levels were set for the attribute CO₂ emissions, an efficient level (100gr per kilometer) and an inefficient level (150gr per kilometer). The attribute biofuels adaptation was included due to the fact that the interest about flexible-fuel vehicles is growing. The flexible fuel vehicles were introduced in the Spanish vehicle fleet from 2007 as a response to the European strategies (Directive 2003/30/EC of the European Parliament and of the Council) directed to motivate the biofuels diffusion in the transport sector. A dichotomous variable of whether the vehicle is equipped or not with this option was considered. In fact, the EU is fighting to reduce its transport greenhouse gas emissions and energy dependence, developing new alternative technologies, and also making great efforts to promote the use of biofuels⁵. Through different policies, the EU encourages the use of biofuel because it is a clean energy, price-competitive with gasoline and diesel, and because its distribution is done using the existing infrastructure (Pacini and Silveira, 2011).

The combination of the five attributes and their levels provides $3 \cdot 2^4 = 48$ possible combinations. In order to reduce the number of combinations, the SPSS software was used to generate an orthogonal fractional factorial design with 8 choice sets. This number of choice sets is optimal to estimate the main effects with a very low level of attribute correlation within and among alternatives. Each one of the 8 created sets contains one alternative, that was called the first alternative. Then, following the Street and Burgess' (2007) procedure, and using a vector of differences (12111), the second alternative was defined for each choice set, achieving a design efficiency of 98%. Each respondent received a sequence of 8 choice sets, while he/she was asked to select his/her preferred alternative in each choice set. In addition, a

⁵ Although very recently the European Commission proposed phase-out of conventional biofuels by 2030 due to their impact on the land use changes (European Parliament, 2015).

no-choice alternative (neither alternative A nor B) was added in order to make the choice more realistic. A card example of the DCE is shown in Figure 2.1.

Figure 2.1 Choice experiment question and Card example

Imagine taking the decision to purchase a new vehicle. Here are several options, A and B, for typical vehicles with different features that are currently sold in the automotive market. Please select the alternative car (car A, car B, neither A or B) you will buy. We present you several choices to select between various cars shown in each set.

	Conventional	Hybrid	Status quo
Price (€)	€16.000	€20.000	Neither A or B
Fuel consumption (€ per 100km)	€7	€5	
Grams of CO ₂ emitted per 1km	150g	100g	
Biofuel adaptation	No	Yes	
<i>I choose</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2.3.2 ECONOMETRIC MODEL SPECIFICATION

The election of alternatives in the DCE is analyzed using random utility models (RUMs) (McFadden, 1974) which properties are derived from Lancaster’s (1966) consumer theory. RUMs express the utility that an individual *i* acquires when he/she chooses an alternative *j* from a set *t* of alternatives *J*, in the following way:

$$U_{ijt} = X'_{ijt}\beta + \varepsilon_{ijt} \tag{2.1}$$

where,

$X'_{ijt}\beta$: represents the part of utility that is observable by the researcher, defined by X'_{ijt} a set of vehicle attributes, and β a vector of parameters (population specific) associated with these attributes.

ε_{ijt} : is the part of utility that is unobservable by the researcher (random error).

Assuming that this error term follows an identically and independent (i.i.d) extreme value distribution, McFadden (1974) derived the multinomial logit model (MNL). The MNL

probability model of choosing an alternative j from each set t of alternatives (conventional, HEV, status quo) may be written as:

$$P_{ijt} = \frac{\exp(X'_{ijt}\beta)}{\sum_{j=1}^J \exp(X'_{ijt}\beta)} \quad (2.2)$$

The MNL model imposes the assumption of independence of irrelevant alternatives (IIA), which results in forcing the taste homogeneity across drivers. An option that may be a good alternative to the MNL model is the latent class model, which captures preference heterogeneity between different groups of drivers and it relaxes the IIA assumption. A latent class model segments the sample into Q unobserved different groups, containing in each group drivers with high preference homogeneity while being significantly different from the other groups. In this way, attribute parameters are distributed discretely over the latent groups (Green and Hensher, 2003; Hensher et al., 2015). The appropriate number of classes to be used is generally selected based on estimated criteria of goodness of fit (AIC, BIC). The probability (H_{iq}) that an individual i belongs to the class q , being $q \in [1, \dots, Q]$, is (Hensher et al., 2015):

$$H_{iq} = \frac{\exp(z'_i \theta_q)}{\sum_{q=1}^Q \exp(z'_i \theta_q)} \quad (2.3)$$

where,

Z_i : is a vector of individual characteristics (covariates variables).

θ_q : is a vector of parameters associated with the covariate variables. The Q -th class is taken as a reference $\theta_Q = 0$.

Given that within a class, the IIA property holds, the probability ($P_{it|q}$) that an individual i , from class q , selects an alternative j in a choice set t is expressed as in eq.(2.2) with the exception of the fact that the parameters are now class specific β_q , and not population

specific. The joint probability ($P_{i|q}$) that individual i , from class q , makes a given sequence of choices is (Hensher et al., 2015):

$$P_{i|q} = \prod_{t=1}^{T_i} P_{it|q} \tag{2.4}$$

Multiplying eq.(2.3) and eq.(2.4) yields to the likelihood of individual i (Hensher et al., 2015):

$$P_i = \sum_{q=1}^Q H_{iq} P_{i|q} \tag{2.5}$$

The WTP of individual i , from class q , for a given attribute “A” may be calculated dividing the estimated parameter ($\hat{\beta}_{iA|q}$) for the attribute “A” by the “PRICE” parameter ($\hat{\beta}_{iP|q}$) (Nguyen et al, 2015).

$$WTP_{iA|q} = (\text{Attribute A} | q) = - \frac{\hat{\beta}_{iA|q}}{\hat{\beta}_{iP|q}} \tag{2.6}$$

For the effect coding attributes, the ratio in eq.(2.6) is multiplied by 2. The average WTP of the sample for the attribute “A” may be obtained by weighting (weighted mean) the class WTP means by the probabilities of the class membership (Kamakura and Russell, 1993; Nguyen et al, 2015) as shown in eq.(2.7).

$$WTP_{iA} = (\text{Attribute A}) = \sum_{q=1}^Q H_{iq} WTP_{iA|q} \tag{2.7}$$

2.4 DATA

The designed DCE was introduced in an online survey, administered in July 2013 to a representative sample (N=878 drivers) of residents over the age of eighteen in Spain and who previously expressed their desire to buy a small or midsize vehicle in the near future. In the sample, 92.46% of households have 1 or more cars. The weekly driving frequency of the sample (4 days) is comparable with the national frequency (5 days) (Spanish Observatory of drivers, 2014). Drivers' current vehicles include a total of 33 different vehicle brands. The most popular brands are Renault (12.46%), following by Ford (11.27%), Citroën (9.93%) and Seat (9.33%). Most drivers' actual vehicles are diesel (54.65%) or gasoline (44.85%), while only 3 drivers have a hybrid vehicle and only 1 driver has a biofuel vehicle. The majority (80.16%) of the drivers are quite or very satisfied with their current vehicles, while the rest are modestly satisfied, little or not satisfied at all.

The survey included a set of questions to capture behavior, attitudes, socioeconomic and demographic characteristics of the drivers. Sample characteristics are shown in Table 2.1. In this sample, 51% of the drivers are male, with a mean age of 46 years, compared to 44 years of national average (Spanish Observatory of Drivers, 2014). Unemployed drivers represent about 18% of the sample, and 24.6% belong to households with monthly income under €1,200. Nearly half (46%) of the sample has university studies.

Table 2.1 Some descriptive statistics

Variables	Description	Mean	Std. Dev
MALE (dummy)	1 for male, 0 for otherwise.	.513	.499
AGE (Continuous)	age of participants (years).	45.972	13.546
LHINC (dummy)	1 for monthly income under €1,200 and 0 otherwise.	.246	.431
UNIV (dummy)	1 for respondents with university studies, 0 for otherwise.	.457	.498
IMAGE (Continuous)	importance (score) attributed for the incentive "social image".	2.744	1.256

In the specified utility function, all five vehicle attributes considered in the DCE were included. The attribute PRICE represents the price of the displayed conventional or HEV hypothetical alternatives. The attribute SAVING-FUEL is an effect coding variable which takes the value +1 if fuel consumption of the displayed vehicle alternative is €5 per 100 kilometers (efficient vehicle), and -1 if it consumes €7 per 100 kilometers (inefficient vehicle). The attribute ABATEMENT-CO2 is an effect coding variable corresponding to the

environmental efficiency of the displayed vehicle alternative, taking the value +1 if the vehicle emits 100 grams of CO₂ per kilometer (efficient vehicle), and -1 if it emits 150 grams of CO₂ per kilometer (inefficient vehicle). The attribute BIOFUEL is an effect coding variable indicating whether the vehicle alternative is equipped to run with biofuels, being +1 if yes and -1 if no. Two dummies variables ASC_c and ASC_h which are alternative-specific constants, representing the first conventional vehicles, and the second HEVs were included to the specification. In addition, a set of driver-specific characteristics (MALE, AGE, LHINC, UNIV, and IMAGE) was used to define the profile of the members who form each particular class. The variables MALE, LHINC, and UNIV are dummies representing respectively drivers, who are male, who earn less than €1,200 per month, and who have university studies. The variable AGE is continuous, representing the age of drivers in years (divided by 10). The variable IMAGE is continuous, and represents how important would be drivers' personal image when buying an efficient car.

2.5 RESULTS AND DISCUSSIONS

In the empirical exercise, the assumption of IIA is tested using the Hausman and MacFadden test. Results [regular car is the omitted alternative: Chi-squared (5) =156.808; HEV is the omitted alternative: Chi-squared (5) =160.883; the 99% critical value: Chi-squared (5) = 15,086] from this test reject the null hypothesis (IIA assumption), implying that the MNL model is not appropriate to fit the current data. In order to relax the IIA assumption and to assess driver preference heterogeneity, a LCM is estimated, making the class allocation as a function of socio-demographic variables (Table 2.1). In order to determine the appropriate number of classes to consider, LCMs with different number of classes (2 classes, 3 classes, 4 classes, 5 classes, and 6 classes) have been estimated. Various overall fit indicators are estimated for each LCM and presented in Table 2.2. All the indicators suggest that LCMs clearly outperform the MNL model. Results show that all the indicators are improving from 2 classes to 5 classes, signaling that the 5-class model has the best fit. The Bayesian information criterion (BIC) is the most appropriate to use in this case because it penalizes for the number of parameters in the model (Roeder et al., 1999). The lowest (best) value of the Bayesian information criterion (BIC) is reached by the 5-class model. However, some authors (Greene, 2014; Hensher et al., 2015) suggested that the existence of potential

over specification should also be assessed when determining the number of classes. In our empirical modeling, the 5-class, and 6-class models are overspecified containing very small groups of drivers (less than 1% of the sample) with un-meaningful estimated parameters (imprecise and insignificant parameters, large standard errors). Therefore, the 4-class model was selected and compared to the MNL model. The predictive power was calculated (see Hensher et al., 2015) as the overall proportion of correct predictions (number of correct predictions/number of observations) for both models, and compare them. As it can be seen at the bottom of Table 2.2, the 4-class model improves the correct prediction rate of the MNL from 43.66% to 70.79%. Table 2.3 shows the final results of the MNL and the 4-class LCM.

Table 2.2 Overall fit of the MNL and the LCMs with sociodemographic variables

	MNL MODEL	2 CLASS MODEL	3 CLASS MODEL	4 CLASS MODEL	5 CLASS MODEL	6 CLASS MODEL
LL	-6,578.013	-5,590.762	-5,263.936	-5,136.378	-4,989.743	-5,370.491
K	6	18	30	42	54	66
N	7,000	7,000	7,000	7,000	7,000	7,000
R-SQRD	.136	.273	.315	.332	.351	.302
R2ADJ	.135	.272	.314	.330	.348	.298
AIC	13,168.0	11,217.5	10,587.9	10,356.8	10,087.5	10,873.0
BIC	13,209.1	11,340.9	10,793.5	10,644.6	10,457.6	11,325.3
Correct predictions	43.66%	60.69%	67.39%	70.79%	77.86%	70.29%

With respect to the results of the multinomial logit model (MNL), it is observable (column 1 of Table 2.3) that all parameters are highly significant, carrying the expected signs, and are in line with previous findings (Achtnicht et al., 2012; Potoglou and Kanaroglou, 2007; Ziegler, 2012). The negative price parameter (PRICE) implies that a driver loses utility when the price attribute (PRICE) increases. This is a reasonable finding given drivers importance placed on this feature when buying a vehicle (Adler et al., 2003). The positive parameters associated with the attributes related to energy efficiency (SAVING_FUEL), environment efficiency (ABATEMENT_CO2) and biofuel adaptation (BIOFUEL) imply that the driver gains utility when the selected vehicle is energy and environmentally efficient and flexible to run with biofuels. In addition, the positive sign of both regular and HEV-specific constants implies that drivers' preferences for entering the new vehicle market and buying a conventional or HEVs are significantly higher with respect to the no choice option (status quo).

Looking at the results of the LCM with 4 classes (column 2 of Table 2.3), it is observable the important heterogeneity in preferences for the attributes across the sample, resulting in

important differences in all the parameters among the 4 classes. Furthermore, the number of attributes that significantly affects drivers' vehicle choices is different across classes. The attributes that affect significantly (at least at 5% level of significance) the vehicle choice in all classes are the price (PRICE), and the type of car (regular or HEV). At first sight, it may be seen that there is a group (third class) that is much more environmentally friendly than the rest because in this class vehicle choices are strongly (at least at 1% level of significance) affected at the same time by environmental efficiency, biofuel adaptation and preferences towards HEVs (compared to conventional cars).

Looking more in detail at the present results, the first class contains the second group of drivers who are less sensitive to price (PRICE) in comparison with the rest of the classes. The effect of energy efficiency on its members' vehicle choice is highly significant, but its magnitude is half than that of the third class. In addition, the environmental efficiency (ABATEMENT_CO2) and biofuel adaptation (BIOFUEL) have significant (at least at 5% level of significance) impact on vehicle choices. With respect to the type of the car, drivers prefer a HEV to the conventional vehicle (ASC_h is statistically larger [Mean (diff) = 1.108; $z=7.70$, $p\text{-value} = .000$] than ASC_c). The members of this class are less likely to earn a monthly income below €1,200 than drivers in the fourth reference class. In accordance with previous findings (Erdem et al., 2010; Liu, 2014), these drivers are more likely to be image seekers than the members of the fourth class. Drivers belonging to this first class are designated as “enthusiastic for HEV but mainly due to aspirational aspects”.

The second class gathers drivers with the lowest sensitivity towards price (PRICE). In addition, neither energy efficiency (SAVING_FUEL) nor biofuel adaptation (BIOFUEL) affects their vehicle choices, while the environmental efficiency (ABATEMENT_CO2) has an intermediate impact on vehicle choices, compared to the rest of classes. Drivers prefer conventional cars over HEVs (ASC_h is statistically lower [Mean (diff) = -0.924; $z=-3.82$, $p\text{-value} = .000$] than ASC_c). They are older than drivers in the fourth class. Additionally, compared to drivers in the fourth class, these in the second class are less likely to be image seekers. The members of the second class may be considered as the “skeptical HEV buyers”.

The third class includes drivers with the highest preference for energy efficiency (SAVING_FUEL), environmental efficiency (ABATEMENT_CO2) and biofuel adaptation (BIOFUEL). They have stronger preferences than the rest for HEVs compared to conventional vehicles (ASC_h is statistically larger [Mean (diff) = 1.218; $z=10.62$, $p\text{-value} = .000$] than ASC_c). It is the only class where all parameters are statistically significant at 1% level. Together with the first class, it contains individuals who worry at the same time about vehicle emissions, biofuel adaptation, and they are HEV-oriented but less affected by price. This result is in accordance with previous studies (Hackbarth and Madlener, 2016) and implies that price is relatively less important for the more pro-environmental groups. In line with previous studies (Abdoolakhan, 2010), members of this class are less likely to be male. Unlike previous studies (Abdoolakhan, 2010; Hidrue et al., 2011), they are more likely to be older than drivers in the fourth reference class. The members of this third class are denoted as “HEV-oriented and conscious drivers”.

The fourth class consists of drivers with the largest sensitivity for price (PRICE) compared to other classes. In addition, the energy efficiency (SAVING_FUEL) has a significant influence on vehicle choices. In contrast, environmental efficiency (ABATEMENT_CO2) has the lowest impact (at 10% level of significance) on vehicle choices, compared to the rest of classes. Together with the second class, they are the only two groups that do not worry about biofuel adaptation. It is the only one class where drivers do not have special preferences for any vehicle type (ASC_h is not statistically different [Mean (diff) = .048; $z=.30$, $p\text{-value} = .765$] to ASC_c). Again, together with the second class, they are the only two classes that do not prefer HEV over conventional vehicles. Members of this class are more likely to be male compared to drivers in the third class, and less probably to be older than those of the second and the third classes. Compared to drivers in the first class, they are more likely to have lower monthly income and less likely to be image seekers. In addition, compared to those of the second class, they are more likely to be image seekers. They are identified as the “good deal seekers.” This is a group that cares in an important way about monetary attributes (PRICE, SAVING_FUEL) but little about the environment (ABATEMENT_CO2).

Table 2.3 Results of the MNL and the LCM (4 classes)

	MNL	LCM			
	Sample	Class 1	Class 2	Class 3	Class 4
Parameters in utility functions					
PRICE	-2.056*** (.055)	-.657*** (.153)	-.450** (.193)	-3.066*** (.220)	-5.361*** (.299)
SAVING_FUEL	.281*** (.017)	.382*** (.063)	.027 (.080)	.728*** (.051)	.438*** (.089)
ABATEMENT_CO2	.255*** (.017)	.139** (.055)	.447*** (.075)	.773*** (.055)	.123* (.066)
BIOFUEL	.100*** (.017)	.112** (.055)	.075 (.098)	.377*** (.046)	.026 (.065)
ASC _c	2.980*** (.084)	3.640*** (.513)	2.854*** (.473)	2.257*** (.242)	10.096*** (.547)
ASC _h	3.402*** (.086)	4.748*** (.520)	1.929*** (.538)	3.476*** (.309)	10.145*** (.490)
Class assignment parameters					
Constant	.	-1.780*** (.626)	-2.589*** (.710)	-.234 (.348)	0.0 (Fixed)
MALE	.	-.112 (.272)	-.098 (.349)	-.527*** (.183)	0.0 (Fixed)
AGE/10	.	.094 (.103)	.264** (.124)	.179*** (.068)	0.0 (Fixed)
LHINC	.	-.930** (.366)	.066 (.430)	-.095 (.199)	0.0 (Fixed)
UNIV	.	-.132 (.265)	-.097 (.363)	-.010 (.179)	0.0 (Fixed)
IMAGE	.	.336*** (.096)	-.001** (.0005)	-.0004 (.0004)	0.0 (Fixed)
CLASS PROB.		.155	.092	.434	.319
Overall fit:					
N	7,000			7,000	
GROUPS	875			875	
NB. OBS./GROUP	8			8	
LL FUNCTION	-6,578.012			-5,136.378	
K	6			42	
CHI SQUARED [K]	.			5,107.814***	
R-SQRD	.136			.332	
ADJ. R-SQRD	.135			.330	
AIC	13,168.0			10,356.8	
BIC	13,209.1			10,644.6	
CORRECT PREDS.	43.66%			70.78%	

(): Standard error; ***, **, *: Significance at 1%, 5%, and 10% level, respectively. To calculate the class membership probabilities, the parameters of the fourth class has been normalized to be 0 (reference class), and the rest of the classes were interpreted with respect to this reference class.

All the class membership probabilities are statistically significant, providing evidence to the existence of heterogeneity across members of our sample. The model allocates 15.5% of the sample in the “enthusiastic for HEV but mainly due to aspirational aspects” group (first class), 9.2% in the “skeptical HEV buyers” group (second class), 43.4% in the “HEV oriented and conscious drivers” group (third class), and 31.9% in the “good deal seekers” group (fourth class). Therefore, from the entire sample, 58.9% (first class + second class) prefer HEVs over conventional vehicles, *ceteris paribus*, although 15.5% (first class) are willing to buy HEVs in part for reputational incentives. This result is quite optimistic about the future of

these vehicles in Spain market. The rest of the sample, although they do not appreciate HEVs compared to conventional vehicles, *ceteris paribus*, they value positively savings in fuel consumption and reductions in CO₂ emissions which are two enhancements included in HEVs.

Table 2.4 summarized the sample WTP for the alternatives and their attributes. The average WTP of the sample in order to update a vehicle, from regular to HEV, in *ceteris paribus* conditions, is €2,476.75, an amount superior to that found by Liu (\$963-\$1,718) (2014). Even so, it is still insufficient to cover the price premium of HEVs. The average WTP of the sample for reductions of €2/100km in fuel costs (SAVING_FUEL) is €4,390.29. An amount that is within the range (€511.42- €5,057.04) found by previous studies (Hackbarth and Madlener, 2016). The sample's mean WTP for reductions of 50gCO₂/km (ABATEMENT_CO2) is €4,827.78. Previous studies reported different WTPs for reductions in emissions, including WTPs of €14-€1,432 (Hackbarth and Madlener, 2016) for the abatement of one percent of CO₂ emissions, €4,230-5,700 for reducing vehicle' pollution to half (Mabit and Fosgerau, 2011), and €3,310 (Hidrué et al., 2011) for reducing vehicle' pollution by 95 percent. Similarly, the sample' mean WTP for biofuels adaptation (BIOFUEL) is €1,599.83. Again, although drivers are willing to pay little for HEVs, they are willing to pay considerable amounts for improvements in reduction of fuel consumption, CO₂ emissions, and biofuel adaptation. This happens because there is a significant percentage (16% of the sample do not know what hybrid cars are like) of drivers who do not relate these improvements with HEVs. Until today, there are a lot of (17% of the sample) drivers who mistake HEVs with EVs; therefore many of them consider that HEVs also suffer from the same problems (mainly related to batteries) as EVs.

Table 2.4 Mean WTP for the alternatives and their attributes across class

Mean WTP	Class 1	Class 2	Class 3	Class 4	Sample
€2 saved in fuel consumption per 100km.	11,648.7*** (3,060.587)	1,232.37 (3,511.762)	4,753.81*** (300.289)	1,635.08*** (295.362)	4,390.29*** (500.136)
50g of CO ₂ reduced in emissions per 1km.	4,255.14** (2,023.200)	19,901.5** (9,260.669)	5,047.03*** (314.378)	460.443* (246.144)	4,827.78*** (890.112)
the car is adapted to run with biofuels.	3,433.47* (1,922.194)	3,346.12 (4,851.710)	2,460.01*** (246.853)	97.843 (246.624)	1,599.83*** (320.903)
To move from regular to HEV	16,858.3*** (4,273.123)	-20,546.3** (9,713.892)	3,975.06*** (280.267)	90.285 (304.761)	2,476.75** (1,193.324)

(): Standard error; ***, **, *: significance at 1%, 5%, and 10% level, respectively.

2.6 CONCLUSIONS AND IMPLICATIONS

Assessing drivers' preferences heterogeneity in the context of vehicle choices is important for public decision makers to segment the market. In this way, they can develop more appropriate policies to promote HEV diffusion strategies and address them to the corresponding target population segment. With the aim of assessing these issues, a DCE is conducted and administered in an online structured survey. Results show that a LCM is more appropriate to capture drivers' preferences heterogeneity than a MNL model. Findings reveal important heterogeneity in preferences over four latent classes labeled as, "enthusiastic for HEV but mainly due to aspirational aspects", "skeptical HEV buyers", "HEV-oriented and conscious drivers" and the "good deal seekers" groups. There exist clear differences in drivers' preferences over these 4 classes. The first and the third groups are clearly pro-environment and HEV-oriented; however the second and the fourth groups prefer conventional vehicles and are price-oriented, respectively, and not interested at all in biofuels. In particular, drivers from the "enthusiastic for HEV but mainly due to aspirational aspects" group represent 15.5% of the sample, they are not very sensitive to price and they are more likely to be wealthy and image seekers compared to the members of the last class "good deal seekers". The "skeptical HEV buyers" are the least sensitive to monetary attributes, they are not affected at all neither by energy efficiency (SAVING_FUEL) nor by biofuel adaptation (BIOFUEL). They are influenced by environmental attributes (ABATEMENT_CO2) and prefer conventional cars to HEVs. They conform 9.2% of the sample and they are more likely to be older drivers and less likely to be image seekers, compared to the fourth class' members. The "HEV-oriented and conscious drivers" are the most affected by energy efficiency (SAVING_FUEL), environmental efficiency (ABATEMENT_CO2) and biofuel adaptation (BIOFUEL) and they strongly prefer HEVs to conventional vehicles. They represent 43.4% of the sample and they are less likely to be male but more likely to be older than the reference class members. The "good deal seekers" are the most sensitive to price (PRICE), and they are less affected or not affected at all by environmental attributes (ABATEMENT_CO2, BIOFUEL). They do not have special preferences for any type of vehicle. They conform 31.9% of the sample and they are more likely to be male, and less likely to be older, when compared to drivers in the third class. They are also less likely to be older and more likely to

be “image seekers” than those of the second class. Moreover, they have less income and they are less likely to be image seekers than those of the first class.

In total, more than half (first and third classes) of drivers prefer HEVs over conventional cars, *ceteris paribus*, even though some of them (first class) do it in part due to reputational purposes. This positive perception towards HEVs is quite optimistic in regards to the future of this technology in the market. It is also found that the sample's average WTP for HEVs is quite small compared to the considerable amounts the sample is willing to pay for improvements in fuel consumption, CO₂ emissions, and biofuel adaptation. This implies that changing drivers' perception for HEVs would boost their demand. Definitively, increasing the attractiveness of HEV's attributes and enhancing their green image will result in more demand for HEVs. However, as it is shown in the present research, the effort that each group is willing to do to reduce air pollution is different, and thus, public policies aimed to promote the use of efficient vehicles may be designed and adopted differently by each group. In particular, public policies should be oriented towards the potential buyer groups of HEVs. Our findings may serve as a guide for possible future public strategies or programs aimed at promoting AFVs. Findings will also help to better explain drivers' preferences when making vehicle choices and to improve our understanding of vehicle choice especially in a context of DCE.

2.7 REFERENCES

Abdoolakhan, Z., 2010. Acceptance of Alternative Fuel and Hybrid Vehicles in Australia – Results Based on Survey Data, Choice Modelling and Elasticity Estimation. Doctoral thesis, The University of Western Australia, Perth.

Achtnicht, M., 2012. German car buyers' willingness to pay to reduce CO2 emissions. *Climatic Change* 113(3-4), 679-697.

Adler, Thomas Wargelin, Laurie Kostyniuk, Lidia Kavalec, Chris and Gary Occhiuzzo 2003. Incentives for alternative Fuel Vehicles: A Large-Scale Stated Preference Experiment, paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, August 2003.

Asociación Española de Fabricantes de Automóviles y Camiones (ANFAC), 2017. http://www.anfac.com/estadisticas.action?accion=estad_turismos (accessed 12.01.17).

Beck, M.J., Rose, J.M., Hensher, D.A., 2013. Environmental attitudes and emissions charging: An example of policy implications for vehicle choice. *Transportation Research Part A* 50, 171-182.

Chua, W.Y., Lee, A., Sadeque, S., 2010, Why do people buy hybrid cars?, in Proceedings of Social Marketing Forum, University of Western Australia, Perth, Western Australia , Edith Cowan University, Churchlands, W.A., pp. 1-13.

Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels or other renewable fuels for transport. *Official Journal of the European Union* 17.05.2003 P.

Ecologists in Action, 2015. Reducir la contaminación en Madrid por la salud y contra el cambio climático. www.ecologistasenaccion.es/article31289.html (accessed 22.07.16).

Erdem, C., Sentürk, I., Simsek, T., 2010. Identifying the factors affecting the willingness to pay for fuel-efficient vehicles in Turkey: A case of hybrids. *Energy Policy* 38 (6), 3038–3043.

European Environment Agency, 2008. Air pollutants and global effects. <http://www.eea.europa.eu/downloads/2d26334d2ea332dc5da4c7647e923174/1461159255/page009.html.pdf> (assessed 14.10.2016).

European Parliament, 2015. Parliament supports shift towards advanced biofuels. <http://www.europarl.europa.eu/news/en/news-room/20150424IPR45730/parliament-supports-shift-towards-advanced-biofuels> (assessed 12.01.2016).

Ewing, G., Sarigöllü, E., 2000. Assessing Consumer Preferences for Clean-Fuel Vehicles: A Discrete Choice Experiment. *Journal of Public Policy and Marketing* 19 (1), 106-118.

Green, W.H., Hensher, D.A. 2003. A latent class model for discrete choice analysis: contrasts with mixed logit. *Transportation Research: Part B: Methodological* 37, 681-698.

Greene, 2014. *Heterogeneity: Latent Class Models*. New York University.

Hackbarth, A., Madlener, R., 2013. Consumer preferences for alternative fuel vehicles: A discrete choice analysis. *Transportation Research Part D* 25, 5–17.

Hackbarth, A., Madlener, R., 2016. Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany. *Transportation Research Part A: Policy and Practice* 85, 89–111.

Hadley, S.W., Tsvetkova, A.A., 2009. Potential Impacts of Plug-in Hybrid Electric Vehicles on Regional Power Generation. *The Electricity Journal* 22 (10), 56–68.

Hensher, D.A., Rose, J.M., Greene, W.H., 2015. *Applied choice analysis*. Second edition, Cambridge University Press.

Hidrué, M.K., Parsons, G.R., Kempton, W., Gardner, M., 2011. Willingness to pay for electric vehicles and their attributes. *Resource and Energy Economics* 33(3), 686-705.

Hoën A, MJ Koetse, 2012, A Choice Experiment on AFV Preferences of Private Car Owners in The Netherlands, PBL Working Paper 3, PBL Netherlands Environmental Assessment Agency, Den Haag, The Netherlands.

Kahn, M.E., 2007. Do greens drive hummers or hybrids? Environmental ideology as a determinant of consumer choice. *Journal environmental economics management* 54 (2), 129–145.

Kamakura, W. A., Russell, G. J. 1993. Measuring brand value with scanner data. *International Journal of Research in Marketing*, 10(1), 9–22.

Klein, J., 2007. Why People Really Buy Hybrids. Topline Strategy Group.

Lancaster K., 1966. A new approach to consumer theory. *The Journal of Political Economy* 74, 132-57.

Lin, H., Chen, W., Conzelmann, G., 2012. Impact of vehicle usage on consumer choice of hybrid electric vehicles. *Transportation Research Part D* 17, 208–214.

Liu Y., 2014. Household demand and willingness to pay for hybrid vehicles. *Energy Economics* 44, 191–197.

Louvière, J.J., Flynn, T.N., Carson, R.T., 2010. Discrete choice experiments are not conjoint analysis. *Journal of choice modeling* 3(3), 57-72.

Mabit, S.L., Fosgerau, M., 2011. Demand for alternative-fuel vehicles when registration taxes are high. *Transp. Res. Part D* 16 (3), 225–231.

McFadden, D. 1974. Conditional logit analysis of qualitative choice behavior. In *Frontiers in Econometrics*, ed. P. Zarembka, New York: Academic Press, 105-42.

Nguyen, T.T., Haider, W., Solgaard, H.S., Jonsen, L.R., Roth, E., 2015. Consumer willingness to pay for quality attributes of fresh seafood: A labeled latent class model. *Food Quality and Preference* 41, 225–236.

Observatory of transport and logistics in Spain (OTLE), 2015. Informe anual 2014. http://observatoriotransporte.fomento.es/NR/rdonlyres/86194B1E-887A-4C21-AC95-8F6F8227840B/129597/INFORME_OTLE_2014.pdf (accessed 10.06.15).

Pacini, H., Silveira, S., 2011. Consumer choice between ethanol and gasoline: Lessons from Brazil and Sweden. *Energy Policy* 39, 6936–6942.

Partridge, Christa, 2013. What Are Hybrid Vehicle Buyers Really Paying For? An Empirical Analysis. All Theses. Paper 1730.

Potoglou, D., Kanaroglou, P.S., 2007. Household demand and willingness to pay for clean vehicles. *Transportation Research Part D* 12(4), 264-274.

Roeder, K., Lynch, K., Nagin, D., 1999. Modeling Uncertainty in Latent Class Membership: A Case Study in Criminology. *Journal of the American Statistical Association* 94,766-76.

Spanish Observatory of Drivers, 2014. Estudio del conductor español: hábitos en los desplazamientos y viajes en vacaciones. <http://www.ducit.es/estudios-ducit> (accessed 10.06.15).

Street, D., Burgess, L., 2007. The construction of optimal stated choice experiments. New Jersey: John Wiley and Sons Inc.

Tanaka, M., Takanori, I., Kayo, M., Lee, F., 2014. Consumers' willingness to pay for alternative fuel vehicles: A comparative discrete choice analysis between the US and Japan. *Transportation Research Part A* 70, 194–209.

Thatchenkery, S.M., Beresteanu, A., 2008. Determinants of automobile demand and implications for hybrid-electric market penetration. Duke University, Durham, North Carolina.

Train, K., 1993, *Qualitative Choice Analysis: Theory Econometrics, and an Application to Automobile Demand*, 3 edn, The MIT Press, Cambridge, Massachusetts.

Toyota, 2016. <http://www.toyota.es/coches/yaris/index.json> (accessed 18.01.2016).

World Health Organization (WHO). 2005. Air quality guidelines for particulate matter, ozone, nitrogen, dioxide and sulfur dioxide. http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf (accessed 18.01.2016).

World health organization (WHO), 2014. Air quality deteriorating in many of the world's cities. <http://www.who.int/mediacentre/news/releases/2014/air-quality/en/> (accessed 20.12.2015).

Ziegler, Andreas. 2012. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. *Transportation Research Part A: Policy and Practice* 46 (8), 1372-1385.

CHAPTER 3

ARE DRIVERS OF LARGER PRIVATE CARS LESS ENVIRONMENTALLY SENSITIVE? EVIDENCE FROM SPAIN



3. ARE DRIVERS OF LARGER PRIVATE CARS LESS ENVIRONMENTALLY SENSITIVE? EVIDENCE FROM SPAIN

Abstract

Understanding heterogeneous preferences for new vehicles, and hybrid electric vehicles (HEVs) in particular, is a key factor in designing appropriate and target-group-specific strategies for promoting sustainable road transport. We use an online discrete choice experiment (DCE) to assess possible differences in preferences for vehicles according to their size. Specifically, we analyze differences in preferences for two groups of drivers: prospective drivers of a small/midsize vehicle, and those who wish to buy a large vehicle. On average, the results provide evidence in favor of Spanish preferences for small/midsize vehicles over larger ones. Furthermore, the results from random parameter logit (RPL) models show that prospective drivers are not, *ceteris paribus*, willing to pay a premium for HEVs compared to conventional vehicles, independently of the vehicle size. However, drivers are likely to pay more for a vehicle with high energy efficiency and low environmental impact, and adapted to run with biofuels. Findings suggest that drivers do not associate reductions in fuel consumption and CO₂ emissions with HEVs. Therefore, public promotion of these improvements is required in order to increase demand for HEVs. Moreover, preferences for CO₂ emissions and HEVs are heterogeneous within drivers of small/midsize vehicles, whereas they are homogeneous among drivers of large vehicles.

3.1 INTRODUCTION

Global warming has increased drastically over the last 20 years. Worldwide CO₂ emissions from fuel combustion, which are the most important causes of global warming, rose from 13,995 to 32,190 million tons of CO₂ between 1971 and 2013. In Spain, CO₂ emissions rose from 119 to 235.7 million tons of CO₂ in the same period, with transport being the main contributor (34.87%) of these CO₂ emissions. The majority (90.26%) of transport sector CO₂

emissions are attributed to road transport, especially in urban areas (International Energy Agency, 2015).

In the last few years, the European Union (EU) has supported the development of new efficient technologies and the improvement of existing conventional vehicles in order to reduce emissions from road transport. The European Parliament and the Council, through the regulation (EC) No 715/2007 (European Parliament and Council, 2007a), defined common limits for emissions from new vehicles (the Euro 5 and Euro 6 standards). The EU expected to reduce the average GHG emissions of new vehicles to 120 g CO₂/km by 2012 (European Parliament and Council, 2007b). Similarly, the Spanish government has required changes in transport in order to attain the major challenge of making private road transport more environmentally friendly, and to meet European requirements. From the 1990s onwards, through Royal Decree 785/2001 (partially implementing Directive 98/70 / EC of the European Parliament and of the Council) the Spanish government required the installation of catalyzers for all gasoline and diesel vehicles, and banned the sale of leaded gasoline (Ministry of the Economy, 2001). In 2007, the Spanish government made changes to the vehicle registration tax (Law 34/2007) so that it was relative to the amount of the vehicle's CO₂ emissions. This tax ranges from 0% for emissions lower than 120 g/km, to 14.75% for emissions of 200 g/km or higher (Head of State, 2007). More recently, various programs have been promoted in Spain, including the *Movea* plan and the *Pive* program, aimed at promoting the adoption of clean and efficient cars. The *Movea* plan provides a subsidy, which varies between €2,700 and €5,500 (depending on its autonomy), in order to help drivers to buy exclusively plug-in hybrid electric vehicles (PHEV)⁶, or hydrogen-powered or electric vehicles (EV). The *Pive* program consists of a direct discount of €1,500 on the purchase of a new vehicle with low emissions (120g of CO₂ per 1 km or less). This program requires participants to turn in a current private vehicle over 10 years of age (7 years for commercial cars).

⁶ Plug-in hybrid electric vehicles (PHEVs) are hybrid electric vehicles (HEVs) which combine internal combustion engines, electric motors and a rechargeable lithium-ion batteries to run (Hadley and Tsvetkova, 2009).

3. ARE DRIVERS OF LARGER PRIVATE CARS LESS ENVIRONMENTALLY SENSITIVE? EVIDENCE FROM SPAIN

Spain has timidly backed the use of alternative fuel vehicles (AFVs)⁷ to substitute the traditional gasoline or diesel vehicles. The use of biogenic fuels has grown following its implantation (2007) in the Spanish automotive market; however, after 2010 the use of these fuels fell. Despite the growth of the use of liquefied petroleum gas (LPG) in automobiles since 2007, its involvement in road transport remains negligible in comparison to conventional fuels. Out of the 1,147,007 passenger vehicles sold in Spain in 2016, 2.70% were hybrid electric vehicles (HEVs)⁸ or PHEVs (ANFAC, 2017). One of the principal causes of this stagnation is the current economic situation. The unemployment rate currently stands at 19.2%, the second highest unemployment rate in the EU after Greece (Eurostat, 2016). Furthermore, the slow development of standards, insufficient incentives, insufficient support for research and development and an unclear vision of infrastructure, among other impediments, are hindering the adoption of these alternative technologies.

The aim of this paper is to assess possible differences in preferences for vehicle type and attributes according to vehicle size. In particular, we test whether drivers interested in small/midsize vehicles have different preferences in terms of the relative importance of automobile attributes (such as CO₂ emissions, energy savings) than those willing to drive larger vehicles. Specifically, we test whether drivers of larger vehicles are less environmental sensitive. Kahn (2007) found that environmentalists were more likely to buy small hybrid vehicles (Honda Civic Hybrid or Honda Insight Hybrid), midsize hybrid vehicles (Toyota Prius Hybrid or Honda Accord Hybrid) or SUVs (Ford Escape Hybrid), but were less likely to purchase small conventional vehicles (Honda Civic or Nissan Sentra), midsize conventional vehicles (Toyota Camry or Honda Accord), or SUVs (Hummers). He also found that positive social interactions raise the demand for hybrid vehicles (especially for the Toyota Prius) among environmentalists. Caulfield et al. (2010) found that people who currently owned small vehicles were more likely to select HEVs. Hidrue et al. (2011) showed that EV-

⁷ Alternative fuel vehicles (AFVs) include biofuel vehicles (BVs), natural gas vehicles (NGVs), fuel cell electric vehicles (FCEVs), electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) (Hackbarth and Madlener, 2013).

⁸ Hybrid electric vehicles (HEVs) combine internal combustion engines (gasoline or Diesel) and electric motors to run. They do not need an external plug to recharge their batteries (Hadley and Tsvetkova, 2009).

orientation increases among people who are more likely to buy a small or medium-sized passenger vehicle as their next purchase. We also calculate the willingness-to-pay (WTP) for the attributes per vehicle size. Moreover, this article provides useful information about the potential of using AFVs, especially HEVs, to reduce the emissions of road transport, and thereby to improve air quality. To achieve these goals, we used a DCE included in an extensive structured online questionnaire to assess drivers' preferences. The findings provide useful information about vehicle choice process and EU Politics aimed at promoting the use of small cars.

3.2 LITERATURE REVIEW

The existing literature (see review of Al-Alawi and Bradley, 2013) on hybrid vehicle choices (both HEV and EVs) have examined several factors that affect vehicle selection, including vehicle-specific attributes (Chua et al., 2010; Erdem et al., 2010; Krupa et al., 2014; Thatchenkery and Beresteanu, 2008), individual socio-demographic characteristics (Erdem et al., 2010; Krupa et al., 2014; Thatchenkery and Beresteanu, 2008), environment attitudes or concerns (Erdem et al., 2010; Krupa et al., 2014; Thatchenkery and Beresteanu, 2008), government incentives (Beck et al., 2013; Thatchenkery and Beresteanu, 2008), and symbolic ideas (Heffner et al., 2007; Chua et al., 2010). The present research is the first study to examine preference variations for vehicle attributes according to their size.

Preferences for hybrid vehicles have been shown to be influenced by vehicle price, fuel consumption, performance (Krupa et al., 2014; Heffner et al., 2007), horsepower, weight (Thatchenkery and Beresteanu, 2008), tax exemptions or reductions (Thatchenkery and Beresteanu, 2008), and emissions charges (Beck et al., 2013). Previous studies (Erdem et al., 2010; Thatchenkery and Beresteanu, 2008) found that high income, higher educational level and environmental concern are strong predictors of preferences for HEVs. Furthermore, different symbolic meanings associated with HEVs including, achieving certain social image (Chua et al., 2010) and owning the latest technology, among others (Heffner et al., 2007) have been shown to play a significant role in HEV choices. Moreover, Axsen et al. (2009) demonstrated the role of neighbor effects in the demand for HEVs, affirming that higher HEV

penetration yielded higher WTP for HEVs. Erdem et al. (2010) estimated that Turks were willing to pay a premium for HEVs of about 858 US\$.

The present research contributes to the existing literature in several ways. It is the first study to compare drivers' preferences for specific attributes in small/midsize and large vehicles. In other words, it tests whether individuals' tastes for automobile attributes and type are different between drivers of small/midsize vehicles and drivers of large vehicles. Vehicle size has been shown to influence vehicle choice (Krupa et al., 2014), although studies have not examined how preferences for vehicle attributes change depending on vehicle size. Choo and Mokhtarian (2004) reported that owners of different sized vehicles have different preferences and attitudes, based on attitudinal questions and socio-demographics. Secondly, consumers' preferences for flex-fuel vehicles are elicited in order to verify whether European strategies (Directive 2003/30/EC) aimed at encouraging the use of biofuels in the transport sector may be successful in the future. Finally, our work analyzes how consumers choose between conventional and HEVs, and implicitly simulates how consumers' responses can be affected by existing public policies or incentives, such as the *Pive* Plan.

3.3 ATTRIBUTES AND THEIR LEVELS IN THE DCE

Previous literature on AFV preferences demonstrated that purchase price and fuel consumption cost (Horne et al., 2005; Mau et al., 2008; Hidrue et al., 2011; Qian and Soopramanien, 2011; Ziegler, 2012; Achtnicht et al., 2012; Hackbarth and Madlener, 2013), carbon dioxide (CO₂) emissions (Achtnicht et al., 2012; Caulfield et al., 2010; Hackbarth and Madlener, 2013; Hackbarth and Madlener, 2016; Potoglou and Kanaroglou, 2007; Ziegler, 2012) may have an important impact on consumer vehicle choices. Based on these findings and public strategies in the transport sector, in addition to these three relevant attributes [purchase price (€), fuel consumption cost (€ per 100km), and CO₂ emissions (g per 1km)], we include vehicle type, and biofuel adaptation in the DCE. Including vehicle type in DCEs (Achtnicht et al., 2012; Hess et al., 2012; Qian and Soopramanien, 2011) makes it possible to compare consumers' preferences between different AFVs, and provides useful information on their market shares. Regarding the inclusion of the biofuel adaptation attribute, the aim is to test whether flex fuel vehicles will be able to increase their market share in the future. Table

3.1 summarizes all the attributes and their corresponding levels included in the DCE. All of the attributes have two possible levels, except the attribute price, which has three levels. The identification of the attribute levels is based on the previously cited literature, and the characteristics of the conventional and HEVs that have sold the most in Spain in the last few years.

Table 3.1 Attributes and levels used in discrete choice experiments

Attributes	Description	Levels	
FTYPE	Fuel type	Conventional HEV	
		Small/midsize cars	Large cars
PRICE	Vehicle price in €	€12, 000	€22, 000
		€16, 000	€26, 000
		€20, 000	€30, 000
FCONSUMPTION	Fuel consumption in € per 100 km	€5	€8
		€7	€10
CO2	CO2 emissions in grams per 1km	100g	130g
		150g	180g
BADAPTATION	Vehicle adapted to biofuels (up to 85% ethanol) or not	No	Si

Note that in the database, the price is coded as P/10000: therefore the estimated parameters have been multiplied by 10000 when computing the WTP estimates.

3.4 SURVEY DESIGN AND DATA COLLECTION

Two versions of DCE were designed, and each respondent received one of these two versions according to the size of their future vehicles reported previously in the survey. Specifically, prior to the DCE, we asked drivers about the size (small, medium, large) they would select for their next vehicle. This anticipated question allowed us to segment our sample on future drivers of small/medium car model, and those who are likely to buy a large car model. The attributes included in the two DCE versions are the same and have the same number of levels, although they are evaluated at different levels. We used an orthogonal design (SPSS) and Street and Burgess' procedure (Street and Burgess, 2005) to combine (design efficiency of 98%) the attributes and their levels in 8 choice situations. An example of choice occasion (card), used in the 'future drivers of small/medium car model' DCE, is shown in Figure 3.1. In each choice occasion, there are a total of three alternatives, including a conventional vehicle, an HEV, and the no-choice alternative (neither conventional nor HEVs). A sequence of 8 different choice occasions was presented to each respondent, where they were asked to choose their favorite alternative in each choice situation.

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Figure 3.1 Choice occasion example

Imagine taking the decision to purchase a new vehicle. Here are several options, A and B, for typical vehicles with different features that are currently sold in the automotive market. Please select the alternative car (car A, car B, neither A or B) you will buy. We present you several choices to select between various cars shown in each set.

Characteristics	Conventional car	Hybrid car	Status quo
Price (€).	€16,000	€20,000	Neither A or B
Fuel consumption (€ per 100km).	€7/100km.	€5/100km.	
Grams of CO2 emitted per 1km.	150g/km.	100g/km.	
Biofuel adaptation	No	Yes	
I choose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The survey includes several structured parts. The first part provides information about the characteristics of the drivers' current cars (type, model, age, price...etc.) and its use (mileage). The second part provides information about certain aspects regarding the decision to purchase the vehicle. The third part requests information about the drivers' attitudes towards environmental issues, while the fourth part gathers information about how the drivers perceive HEVs. In the fifth part, the drivers are asked about the characteristics of their possible next vehicles. The sixth part corresponds to the DCE. Finally, the survey collects information on socio-demographic characteristics (gender, age, income, studies), among others.

3.5 DISCRETE CHOICE MODELING: RANDOM PARAMETER LOGIT (RPL) MODEL

In the context of DCEs, the random utility models assume that an individual analyzes all of the alternatives available in a choice occasion, and that they always choose the alternative which maximizes their utility or satisfaction (Lancaster, 1966). Under the RPL model, the utility that an individual i ($i=1,\dots,I$) derives from choosing a given alternative a among a set of J alternatives presented in a choice situation t can be presented as (Hensher and Greene, 2001; Brownstone et al., 2000; Revelt and Train, 1998):

$$U_{iat} = \beta_i' x_{iat} + \varepsilon_{iat} \tag{3.1}$$

where,

x_{iat} : is a vector of observed characteristics of the alternative a and the individual i ; β_i is a vector of the tastes which changes in the population according to the density function $f(\beta_i|\Omega)$ where Ω are the moments of this distribution. ε_{iat} is a random term assumed to be independent and identically distributed (iid) extreme value type 1 (Hensher and Greene, 2001; Brownstone et al., 2000; Revelt and Train, 1998).

Depending on the value of β_i , the conditional choice probability is a logit probability expressed as (Hensher and Greene, 2001; Mcfadden and Train, 2000; Revelt and Train, 1998):

$$L_{iat}(\beta_i) = \frac{\exp(\beta_i' x_{iat})}{\sum_j \exp(\beta_i' x_{ijt})} \quad (3.2)$$

The unconditional choice probability is the integral of eq.(3.2) over the values of β_i (Hensher and Greene, 2001; Mcfadden and Train, 2000; Revelt and Train, 1998):

$$P_{iat} = \int L_{iat}(\beta_i) f(\beta_i|\Omega) d\beta_i \quad (3.3)$$

The RPL allows any distribution for the density $f(\beta_i|\Omega)$ (Mcfadden and Train, 2000; Train, 2003). So, RPL does not require the assumption of independence of irrelevant alternatives (IIA assumption) and allows for flexible substitution patterns (Train, 2003). Given that the eq.(3.3) cannot be evaluated in a finite number of operations, we have to simulate it (Brownstone et al., 2000).

In a DCE, respondents make repeated choices over time; therefore, it is likely that the unobserved factors are correlated over time and alternatives. Unlike MNL, the RPL may be specified accommodating correlation over time or alternatives. The utility expression eq.(3.1) can be rearranged as (Hensher and Greene, 2001; Revelt and Train, 1998):

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$$U_{iat} = b'x_{iat} + \eta_i'x_{iat} + \varepsilon_{iat} \quad (3.4)$$

where the parameter vector $\beta_i = b + \eta_i$ is divided into a population mean b and a random part η_i which represents the dispersion of individual's tastes from the mean. Unlike ε_{iat} (independent over time and alternatives), $\eta_i'x_{iat} + \varepsilon_{iat}$ is correlated over time or alternatives. This implies that the covariance between two alternatives a and j is (Hensher and Greene, 2001): $\text{Cov}[(\eta_i'x_{iat} + \varepsilon_{iat}), (\eta_i'x_{ijt} + \varepsilon_{ijt})] = \sigma^2(X_{iat}X_{ijt})$ where, σ^2 is the variance of η_i . $\eta_i'x_{iat}$ maybe also correlated over time, thus the covariance between time t and s is: $\text{Cov}[(u_iX_{iat} + \varepsilon_{iat}), (u_iX_{ijs} + \varepsilon_{ijs})] = \sigma^2(X_{iat}X_{ijs})$ (Hensher and Greene, 2001).

In this work, we use the following six attributes to explain drivers' car choices: PRICE, FCONSUMPTION, CO2, BADAPTATION, ASC_c , and ASC_h , corresponding to purchase price, fuel consumption costs (€ per 100km), CO2 emissions (g of CO2 per 1km), biofuels adaptation (flex-fuel), and a regular vehicle-specific constant, and HEV-specific constant, respectively. The variables price (PRICE), fuel consumption (FCONSUMPTION), and CO2 emissions (CO2) are linear (continuous) and the rest are dummy-variables. We first estimated a multinomial logit (MNL) widely used in the existing literature (Axsen et al., 2009; Qian and Soopramanien, 2011; Mau et al., 2008) in the context of preferences for AFVs. In order to check whether the IIA assumption is valid for our data, we conducted the Hausman Chi-square test (Hausman, 1978), which determines whether there are significant systematic differences between estimates of a full MNL and a similar MNL where we omitted an alternative (Regular or HEV). The results [small/midsize cars: regular car omitted: $\chi^2(5) = 156.808$; HEV omitted: $\chi^2(5) = 160.883$; the 99% critical value: Chi-squared (5) = 15,086 and large vehicles (regular car omitted: $\chi^2(5) = 16.01$; HEV omitted: $\chi^2(5) = 17.29$; the 99% critical value: Chi-squared (5) = 15,086] reject the IIA hypothesis. This suggests that the use of the RPL is more appropriate and justified. For this reason, several RPL models have been estimated. In the estimated RPL models, we assume that the parameters associated with the price (PRICE), fuel consumption (FCONSUMPTION), and CO2 emissions (CO2) to be log-normally distributed in order to account for negative preferences for these attributes. The two constants (ASC_c , and ASC_h) are assumed to be normally distributed, given that drivers may

like or dislike these vehicle types. As regards the parameter associated with biofuel adaptation (BADAPTATION), this was selected to be non-random, as the standard deviations of various distributions were not significant.

Given that every one of our drivers completed a sequence of 8 choice sets, all of the estimated RPL models are specified in a way that correlated choice sets are accommodated across each individual. In particular, we estimate several RPL models, including an RPL where we assume uncorrelated random parameters, an RPL with correlated random parameters (unobserved effects in different choice sets from a given individual are correlated), and an RPL where we assume correlated random parameters and explore the sources of revealed preferences heterogeneity around the mean of the two vehicle type constants. In this last model, we use the following explanatory variables: MALE (male), AGE (respondent's age in years), LHINC (monthly income under €1,200), KNOWLEDGE (drivers who know other hybrid car owners), FREQDRIVE (drivers who drive more than the average daily driving distance for the sample), IMAGE (importance attributed for the incentive "social image"), and ENVORG (drivers belonging to environmental organizations) to be sources of heterogeneity in the mean of the two vehicle specific constants.

In order to provide more critical information for policy makers, we estimate drivers' willingness to pay (WTP) for HEVs associated with the improvements in its attributes. In the case of the MNL model, the WTP for an attributes is generally estimated by dividing the parameter estimated for that attribute of interest (β_{Attr}) by that of the price attribute (β_p) as shown in the following formula (Train, 2009):

$$WTP\{\text{Attribute "Attr"}\} = \frac{\beta_{Attr}}{\beta_p} \quad (3.5)$$

However, in the case of RPL, we construct the WTPs based on population parameter estimates (unconditional estimates). The WTP based on unconditional parameter estimates are obtained simulating the population (Hensher et al., 2015). The fact that the PRICE coefficient is assumed to be log-normally distributed ensures the existence of moments for the distributions of the willingness to pay (WTPs) (Daly et al., 2012).

3.6 SAMPLE CHARACTERISTICS

The survey was conducted online with a random sample in Spain during July 2013, and was addressed to a representative sample of 1,016 residents over the age of 18. By vehicle size, 878 drivers are likely to buy a small/midsize vehicle model in the future, whereas only 138 drivers prefer buying a large vehicle model. Some drivers' socio-demographic characteristics according to vehicle size are shown in Table 3.2. Looking at future drivers of small/midsize vehicle models, the average age is 46 years, and more than fifty-six percent lived in households with three or more individuals. Fifty-one percent of drivers were male, and forty six percent of subjects had university studies. One fifth of drivers were unemployed, and seventy-five percent of all households received a monthly income exceeding €1,200. Regarding future drivers of large vehicles, the average age is 45 years and more than seventy-one percent lived in households with three or more individuals. Fifty-seven percent of drivers were male, and fifty percent of subjects had university studies. Sixteen percent of drivers were unemployed and eighty five percent of all households received a monthly income exceeding €1,200. According to the data from the Spanish General Directorate for Traffic 2013 Census (DGT, 2013), our sample is representative at least for some characteristics of the drivers, including driving frequency, age and gender.

Table 3.2 Descriptive statistics of some variables included in the RPL models

Variable	Description	Small/midsize cars		Large cars	
		Mean	Std. Dev.	Mean	Std. Dev.
MALE (Dummy)	1 for male and 0 otherwise.	.513	.499	.572	.494
AGE (Continuous)	age of participants (years).	45.972	13.546	44.710	11.578
LHINC (Dummy)	1 for respondents who earn monthly under €1,200 and 0 otherwise.	.246	.431	.152	.359
KNOWLEDGE (Dummy)	1 for respondents who know hybrid car owners and 0 otherwise.	.276	.447	.333	.471
FREQDRIVE (Dummy)	1 for respondents who drive more than the average daily driving distance for the sample (more than 20 kilometers) and 0 otherwise.	.560	.496	.304	.460
IMAGE (Continuous)	importance (score) attributed for the incentive "social image".	2.744	1.256	2.600	1.345
ENVORG (Dummy)	1 for respondents belonging to environmental organization and 0 otherwise.	.090	.286	.123	.328

3.7 RESULTS AND DISCUSSION

3.7.1 PREFERENCES FOR HEV AND ITS ATTRIBUTES

Most (86.41%) of the drivers would prefer to buy a small or a midsize vehicle on the next occasion. The probabilities of choosing a HEV, a conventional vehicle or the status quo among the future drivers of small/midsize vehicle models, are .40, .30, and .30, respectively. Within the future drivers of large vehicle models, the probabilities of choosing an HEV, a conventional vehicle or the status quo are .30, .24 and .46, respectively. The results indicate that independently of vehicle size, the choice of HEVs exceeds that of conventional vehicles. Also, the probability of selecting HEVs is higher between future drivers of small/medium vehicle models than those who are likely to buy a large vehicle model. These findings are comparable to those of Caulfield et al. (2010), but they contradict those of Hackbarth and Madlener (2012).

Independently of vehicle size, all RPL models fit the data better than the MNL. According to Revelt and Train (1998), a log-normal term β_i may be expressed as: $\beta_{ik} = \exp(b_k + s_k \mu_{ik})$ where k is an element of β_i ; μ_{ik} is a draw from the standard normal deviate; b_k and s_k are the mean and the standard deviation of $\log(\beta_{ik})$. The mean ($\exp(b_k + (s_k^2/2))$) and the standard deviation ($\text{mean} * \sqrt{\exp(s_k^2) - 1}$) of β_{ik} (Revelt and Train, 1998) are presented in Table 3.3.

Furthermore, the standard deviations presented in Table 3.3 are dependent contributions of the random parameters because they include the part of variance due exclusively to each corresponding random parameter (independent contribution), and the part attributable to the cross-correlated parameter terms. Table 3.3 also presents the Cholesky decomposition matrix, which separates the size of the variance due exclusively to each random parameter (diagonal values of the Cholesky matrix) and the part attributable to cross-parameter correlations (off-diagonal values) (Hensher and Li, 2010).

3.7.2 FUTURE DRIVERS OF SMALL/MEDIUM VEHICLE MODELS

Column 1 shows the results of the multinomial logit (MNL) model. All the estimated parameters are statistically highly significant, have the expected signs, and are similar to existing findings (Adler et al., 2003; Shin et al., 2015; Potoglou and Kanaroglou, 2007). While increases in price (PRICE), fuel consumption (FCONSUMPTION) or CO₂ emissions (CO₂) decrease drivers' utility, the fact that the car is adaptable to flexible fuel (adaptable to run with biofuels) has a positive effect on utility. Furthermore, both vehicle-specific constants are statistically significant and have positive signs, implying that drivers are more satisfied choosing either of the two vehicles (conventional or HEVs) than staying with the non-car option (status quo). Moreover, the difference between the two constants is statistically significant [$\text{diff}(\text{ASC}_h - \text{ASC}_c) = .422$; $p\text{-value} = .000$], indicating that drivers also show stronger *ceteris paribus* preference for HEVs than regular vehicles. These *ceteris paribus* preferences for HEVs over conventional vehicles are in line with previous findings (Caulfield et al., 2010).

Columns 2 and 3 respectively show the results of the RPL with independent random parameters (RPL1) and the RPL with correlated parameters (RPL2). The RPL2 provides a better fit (according to LL FUNCTION, R-SQUARED, ADJUSTED R-SQUARED, AIC and BIC) to the RPL1, implying that the model assuming that uncorrelated random parameters (RPL1) is too restrictive. Therefore, and for the sake of brevity, we discuss the results of the RPL2. The mean effects of both random and nonrandom parameters are highly statistically significant. The signs of the parameters are as expected, and similar to those found previously in the estimated MNL model. All of the standard deviations (dependent contribution) of the random parameters are statistically significant, suggesting the presence of a substantial amount of heterogeneity in individuals' preferences for the price, fuel consumption, and CO₂ emission attributes; as well as for the conventional and HEV indicators. Price and the conventional car specific constant (ASC_c) present the standard deviations with the highest values, reflecting the significant amount of heterogeneity in terms of the tastes of future drivers of small/medium car model for these attributes. However, according to the diagonal elements in the Cholesky decomposition matrix, only three of the diagonal elements are statistically significant, suggesting that only the independent contribution (attribute-specific

standard deviation) of the parameters of PRICE, FCONSUMPTION, and CO2 are statistically significant. Thus, the heterogeneity associated with the two vehicle constants is exclusively due to the correlation between the constants and the other parameters. If we consider the matrix correlation, it can be seen that some parameters are highly correlated; in particular between the two constants (.951), suggesting that individuals with strong preferences for conventional vehicles are likely to have strong preferences for HEVs. There is also a high correlation between fuel consumption and CO2 emissions (-.935), indicating that strong preferences for a vehicle with high energy efficiency reflect weak preferences for a vehicle with low environmental impacts. There is also a high correlation between the price and the two constants (-.783 and -.735 with ASC_c, and ASC_h, respectively), suggesting that individuals with large marginal disutility for price are likely to have lower marginal utility for both regular and HEVs, being more likely to remain in the status quo (no car selection). The below-diagonal values in the Cholesky matrix show statistically significant cross-parameter correlations (attribute-interaction standard deviations) between PRICE and ASC_c, PRICE and ASC_h, FCONSUMPTION and CO2, FCONSUMPTION and ASC_h, CO2 and ASC_c, CO2 and ASC_h. Thus, all of these cross-parameter terms have significant contributions in the variance of the corresponding random parameters.

Column 4 shows the results of an RPL model (RPL3), which consists of RPL2 plus heterogeneity around the mean of the vehicle-specific constants. The results show that male are more likely to select conventional or HEVs compared to the no-choice option, whereas older drivers with low incomes are less likely to choose neither compared to the status quo. Some related studies have found that males prefer AFVs more than women (Ziegler, 2012), younger drivers prefer HEVs more than older drivers, (Hackbarth and Madlener, 2012; Shin et al., 2015), and that prospective drivers with lower incomes prefer conventional cars over HEVs (Shin et al., 2015). Furthermore, in line with previous studies (Chua et al., 2010), drivers who consider their social image to be very important when buying a new vehicle are more likely to choose HEVs over the no-choice option in the DCE.

3.7.3 FUTURE DRIVERS OF LARGE VEHICLE MODELS

Column 6 shows the results of the estimated MNL model. Regarding the signs and the statistical significances of the effect of the attributes, it is clear that the results are similar to those found for future drivers of small/medium vehicle models. According to the difference between the two constants [$\text{diff}(\text{ASC}_h - \text{ASC}_c) = .313$; $p\text{-value} = .000$], future drivers of large vehicle models are, *ceteris paribus*, also more likely to select HEVs than regular vehicles. However, there are some differences related to the structure of the attributes that significantly affect the vehicle choice according to the vehicle size. In particular, future drivers of large vehicles consider fuel consumption (FCONSUMPTION) as less important than biofuel adaptation (BADAPTATION), while those who are likely to buy a small/medium vehicle model do the opposite. There are also important differences in the magnitude of the parameters, especially in terms of the price attribute. Precisely, while the effect of price is much more important when choosing between small/medium vehicles, both the effects of fuel consumption and CO2 emissions are very similar (if not the same) across the two vehicle size categories. The high price effect on vehicle choice of future drivers of small/medium vehicle models may be due to the low level (24.6% earn monthly under €1,200) of their income compared to those of future drivers of large vehicles (15.2% earn monthly under €1,200). Regarding emissions, drivers of larger vehicles are not less environmental sensitive. Therefore, there are many reasons (family size, need for work, etc.) for drivers to choose a large vehicle over a small/midsize vehicle, but this does not imply that they do not care about the environment. Also, drivers do not choose small vehicles exclusively for environmental issues, but for other reasons (cheaper, more comfortable to park, easier to drive, etc.). Moreover, future drivers of large vehicles are more sensitive to flex fuel vehicles than future drivers of small/medium vehicle models. Columns 7 and 8 present the results of the RPL with independent parameters (RPL1) and the RPL with correlated parameters (RPL2), respectively. Unlike the case of future drivers of small/midsize vehicle models, the RPL2 (BIC=1,672.0) does not improve the fit of RPL1 (BIC=1,633.8), implying that the model assuming uncorrelated random parameters (RPL1) is flexible enough to explain the drivers' preferences. For this reason, we proceed to explain the results of the RPL1. As may be seen in column 7, the means of both the nonrandom and random parameters are significant, with expected and similar signs to those provided by the MNL model. However, in the RPL1, the effect of fuel

consumption is greater than that of biofuel adaptation. Regarding the standard deviations, only those associated with price, fuel consumption (at 10%) and the constant reflecting the conventional vehicle are statistically significant, revealing that individuals' tastes are heterogeneous for these attributes. However, the standard deviation of CO₂ emissions and the HEV constant are not statistically significant, indicating that drivers' preferences for these two characteristics are homogeneous, unlike those of future buyers of small/midsize vehicle models. Column 9 shows the results of the RPL model with correlated parameters and heterogeneity around the mean of the constants (RPL3). Unlike small/midsize vehicles, and as found by Ziegler (2012), the results show that men are less likely to choose any of the vehicles compared to the no-choice option. Moreover, drivers who consider their social reputation to be very important when buying a new vehicle are more likely to choose conventional or HEVs over the status quo.

In general, we find that both drivers of small/midsize vehicles and drivers of large vehicles, *ceteris paribus*, prefer HEVs over conventional vehicles (although the figures are slightly higher for the former group). Furthermore, the results show that drivers of small/midsize vehicles are much more sensitive to price. Drivers of large vehicles have an identical pattern of preferences for environment attributes to that of drivers of small/midsize vehicles. In addition, we show that the preferences of drivers of small/midsize vehicles are more heterogeneous than those of drivers of large vehicles.

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Table 3.3 Results of the estimated models

	Future drivers of small/midsize vehicles				Future drivers of large vehicles			
	MNL	RPL1	RPL2	RPL3	MNL	RPL1	RPL2	RPL3
Parameters in utility functions								
PRICE	-2.056*** (.055)	-3.085*** (.085)	-3.578*** (.244)	-3.150*** (.140)	-1.571*** (.144)	-2.761*** (.258)	-3.368*** (1.025)	-2.882*** (.848)
FCONSUMPTION	-.281*** (.017)	-.462*** (.027)	-.533*** (.035)	-.433*** (.040)	-.278*** (.046)	-.516*** (.113)	-.568*** (.163)	-.616*** (.168)
CO2	-.010*** (.001)	-.021*** (.003)	-.022*** (.004)	-.017*** (.001)	-.011*** (.001)	-.023*** (.007)	-.025** (.013)	-.032* (.019)
BADAPTATION	.200*** (.034)	.257*** (.042)	.292*** (.044)	.262*** (.046)	.347*** (.091)	.489*** (.116)	.534*** (.126)	.619*** (.149)
ASC _c	5.844*** (.178)	9.928*** (.248)	11.302*** (.476)	9.835*** (.494)	7.263*** (.694)	13.738*** (1.162)	14.927*** (1.918)	10.712*** (3.779)
ASC _h	6.267*** (.181)	10.571*** (.251)	12.020*** (.488)	10.146*** (.459)	7.576*** (.705)	14.281*** (1.178)	15.542*** (1.904)	9.882*** (3.253)
Heterogeneity in mean, Parameter * Variable								
ASC _c *MALE				.745*** (.181)				-2.357* (1.272)
ASC _c *AGE				-.021*** (.007)				.040 (.066)
ASC _c *LHINC				-.584*** (.182)				.613 (2.120)
ASC _c *KNOWLEDGE				.090 (.141)				-.475 (1.417)
ASC _c *FREQDRIVE				.079 (.122)				.462 (1.296)
ASC _c *IMAGE				.118 (.077)				1.446*** (.537)
ASC _c *ENVORG				-.074 (.231)				-2.185 (1.863)
ASC _h *MALE				.661*** (.168)				-2.657** (1.197)
ASC _h *AGE				-.013** (.006)				.068 (.055)
ASC _h *LHINC				-.642*** (.179)				1.392 (1.762)
ASC _h *KNOWLEDGE				.110 (.131)				.045 (1.101)
ASC _h *FREQDRIVE				.017 (.114)				.252 (1.089)
ASC _h *IMAGE				.175** (.070)				1.567*** (.512)
ASC _h *ENVORG				.035 (.202)				-2.218 (1.902)
Standard deviations of random parameters (dependent contribution)								
LSPRICE	.	1.209*** (.106)	2.854*** (.486)	1.986*** (.246)	.	1.263*** (.281)	3.646 (2.409)	3.134 (2.067)
LSFCONSUMPTION	.	.339*** (.058)	.242*** (.064)	.378*** (.066)	.	.334* (.201)	.321 (.379)	.372 (.351)
LSCO2	.	.025*** (.007)	.030** (.014)	.009*** (.001)	.	.023 (.017)	.029 (.035)	.052 (.066)
NSASC _c	.	1.145*** (.086)	4.740*** (.549)	3.499*** (.288)	.	1.538*** (.410)	4.210* (2.210)	4.58149* (2.486)
NSASC _h	.	.205 (.446)	4.523*** (.603)	3.061*** (.282)	.	.564 (.938)	4.068 (2.547)	3.283 (2.545)

Table 3.3 Results of the estimated models (continued)

	Future drivers of small/midsize vehicles				Future drivers of large vehicles			
	MNL	RPL1	RPL2	RPL3	MNL	RPL1	RPL2	RPL3
Diagonal values in Cholesky matrix, L. (independent contribution)								
LSPRICE	.	.	.701*** (.064)	.578*** (.045)	.	.	.880*** (.249)	.883*** (.250)
LSFCONSUMPTION	.	.	.421*** (.089)	.740*** (.064)	.	.	.417 (.412)	.272 (.467)
LSCO2	.	.	.351*** (.121)	.485*** (.071)	.	.	.241 (.350)	.225 (.348)
NSASC _c	.	.	.141 (1.014)	.423*** (.132)	.	.	2.292 (1.997)	2.297 (1.699)
NSASC _h	.	.	.829 (.617)	.763*** (.063)	.	.	.929 (2.453)	.606 (2.222)
Below diagonal values in L matrix. V = L*Lt								
FCONSUMPTION:PRICE	.	.	-.099 (.093)	-.137** (.068)	.	.	.321 (.357)	-.48690* (.272)
CO2 : PRICE	.	.	.132 (.142)	-.102 (.075)	.	.	.590 (.480)	-1.072** (.435)
CO2 : FCONSUMPTION	.	.	-.960*** (.166)	.015 (.100)	.	.	-.641 (.461)	.288 (.494)
ASC _c : PRICE	.	.	-3.712*** (.656)	2.437*** (.329)	.	.	-2.868 (2.715)	3.173 (2.572)
ASC _c : FCONSUMPTION	.	.	-.581 (.701)	2.059*** (.284)	.	.	-.806 (4.012)	1.342 (3.667)
ASC _c : CO2	.	.	2.887*** (.311)	-1.373*** (.184)	.	.	1.896 (1.804)	1.959 (2.119)
ASC _h : PRICE	.	.	-3.327*** (.648)	2.106*** (.326)	.	.	-2.318 (2.796)	2.208 (2.549)
ASC _h : FCONSUMPTION	.	.	-1.364* (.698)	1.911*** (.280)	.	.	-1.194 (4.300)	1.036 (3.655)
ASC _h : CO2	.	.	2.545*** (.385)	-.700*** (.202)	.	.	2.761* (1.483)	.659 (2.330)
ASC _h : ASC _c	.	.	-.597 (.957)	-.457*** (.119)	.	.	1.122 (2.664)	-2.006 (1.430)
STATISTICS:								
N	7,000	7,000	7,000	7,000	1,104	1,104	1,104	1,104
GROUPS	875	875	875	875	138	138	138	138
NB. OBSRVS./GROUP	8	8	8	8	8	8	8	8
LL FUNCTION	-6,578.012	-5,287.501	-5,190.921	-4,667.186	-1,072.780	-778.377	-762.422	-694.334
K	6	11	21	35	6	11	21	35
LRT:								
CHI SQUARED [K]	.	4,805.568	4,998.729	4,112.640	.	866.783	898.693	894.247
SIGNIFICANCE	.	.000	.000	.000	.	.000	.000	.000
R-SQUARED	.136	.312	.325	.306	.084	.357	.371	.391
ADJ. R-SQUARED	.135	.311	.324	.304	.082	.354	.365	.381
AIC	13,168.0	10,597.0	10,423.8	9,404.4	2,157.6	1,578.8	1,566.8	1,458.7
BIC	13,209.1	10,672.4	10,567.8	9,644.3	2,187.6	1,633.8	1,672.0	1,633.9
REPLICATIONS	.	2,000	2,000	2,000	.	2,000	2,000	2,000
SIMULATION	.		Halton		.		Halton	

MNL: Multinomial logit model; RPL1: Random parameter logit model with uncorrelated parameters; RPL2: Random parameter logit model with correlated parameters; RPL3: Random parameter logit model with correlated parameters and heterogeneity in means.

3.7.4 WTP FOR HEV AND ITS ATTRIBUTES

Table 3.4 shows that, *ceteris paribus*, drivers' WTP to change from a conventional to a HEV is 0 among both, large and small/medium vehicle drivers. However, drivers are willing to pay €1,925.882 for each €1 saved in fuel expenses per 100 kilometers (fuel consumption cost) in the small/midsize vehicle category versus €2,348.404 in the large vehicle category. In addition, drivers are willing to pay €81.417 for each 1g of CO₂ reduced in small/midsize vehicle emissions per 1 kilometer versus €140.656 in the large vehicle model. The maximum WTP for a small/midsize vehicle to be adaptable to biofuels is €942.418 versus €2,109.028 in the large vehicle category. Therefore, in both cases, drivers are willing to pay a premium for a vehicle with low fuel consumption, low CO₂ emissions and biofuel adaptation, although they are not, *ceteris paribus*, likely to pay more for HEV compared to a conventional vehicle. The WTPs of future drivers of small/medium vehicle models for each one of the three attributes are lower than those for drivers are likely to buy a large vehicle model. This result may be due to the fact that future drivers of small/medium car models believe that a small or medium vehicle is energetically and environmentally efficient, and therefore allows for very small margins in fuel savings and CO₂ reductions. However, those who are likely to buy a large vehicle model are those who can save a large amount in fuel consumption and reductions in CO₂ emissions.

Table 3.4: Mean WTP estimates

Attribute/Alternative	Small/midsize cars			Large cars		
	Mean	Std. Dev.	Prob. |z| > Z	Mean	Std. Dev.	Prob. |z| > Z
€1 saving in fuel consumption per 100km.	€1,925.882	€899.999	.017	€2,348.404	€993.960	.007
1g abated in CO ₂ emissions per 1km.	€81.417	€40.402	.022	€140.656	€69.881	.020
to be adapted to run with biofuels.	€942.418	€375.042	.006	€2,109.028	€831.698	.005
to move from conventional to HEV.	€625.433	€1,324.805	.308	€858.294	€1,930.714	.326

Note: WTP estimates are based on the results of the RPL models with independent parameters (RPL1).

3.8 CONCLUSION

This paper shows the heterogeneity in preferences and willingness to pay (WTP) for vehicle attributes and type by studying the stated choices of two groups of individuals: future drivers of a small/medium car model, and those who are likely to buy a large vehicle model.

In particular, the preferences of 1,016 Spanish drivers are assessed via DCE included in a structured online survey. MNL model and RPL models are estimated to examine individual discrete choices. The results show drivers' preferences for small/midsize vehicles over large vehicles. According to our results, they choose small/midsize vehicles due to their lower prices, lower consumptions, and lower CO₂ emissions. These results are highly relevant for future mobility plans, and could be helpful for possible future policy.

The results of an MNL show that for both vehicle sizes, increases in price, fuel consumption or CO₂ emissions reduce new vehicle demand, whereas the fact that the vehicle is adaptable to flexible fuel (adaptable to run with biofuels) increases its selection. We also found that regardless of vehicle size, HEVs are *ceteris paribus* preferred over conventional vehicles, albeit to a slightly higher degree among drivers of small/midsize vehicles. Furthermore, the results show that drivers of small/midsize vehicles are much more sensitive to price, which could be attributed to their low earnings. Moreover, we find that drivers of large vehicles are equally sensitive (compared to drivers of small/midsize vehicles) to environmental attributes, and even more for the use of biofuels. We also show that preferences of drivers of small/midsize vehicles are more heterogeneous than those of the drivers of large vehicles. This result implies that environmental policies should be more general when they are aimed at drivers of large vehicles, and more personalized for drivers of small/midsize vehicles. The results also show that in the case of small/midsize vehicles, males are more likely to prefer HEVs, whereas when they choose between large vehicles, they are less likely to choose HEVs. Additionally, drivers who consider their social image to be very important when buying a new vehicle are more likely to choose HEVs in the case of small/midsize vehicles, and conventional or HEVs in the case of large vehicles. This means that image-seeking drivers are more likely to choose HEVs when selecting among small/midsize vehicles than when they face a choice between large vehicles.

In addition, the results show that drivers are not, *ceteris paribus*, willing to pay a premium either for small/midsize HEVs or large HEVs compared to conventional vehicles. However, drivers are likely to pay more for a vehicle with low fuel consumption, low CO₂ emissions, and which is adopted to run with biofuels. The results show that the participants' WTPs for large vehicle attributes are higher than those estimated for small/midsize vehicles.

The findings suggest that drivers do not associate improvements in fuel consumption and CO₂ emissions with HEVs in both vehicle size classes. Therefore, public promotion of these improvements would increase drivers' demands for HEVs. Encouraging the use of these vehicles by public authorities, as taxis, and as public transport would make them popular and more desired. Finally, we conclude that HEVs and environmental policies should be more targeted towards drivers who support this technology (such as image seekers).



3.9 REFERENCES

Achtnicht, M., 2012. German car buyers' willingness to pay to reduce CO2 emissions. *Climatic Change* 113(3-4), 679-697.

Adler, Thomas Wargelin, Laurie Kostyniuk, Lidia Kavalec, Chris and Gary Occhiuzzo 2003. Incentives for alternative Fuel Vehicles: A Large-Scale Stated Preference Experiment, paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, August 2003.

Al-Alawi, B.M., Bradley, T.H., 2013. Review of hybrid, plug-in hybrid, and electric vehicle market modeling studies *Renew. Sustain. Energy Rev* 21, 190–203.

Asociación Española de Fabricantes de Automóviles y Camiones (ANFAC), 2017. http://www.anfac.com/estadisticas.action?accion=estad_turismos (accessed 12.01.17).

Axsen, J., Mountain, D.C., Jaccard, M., 2009. Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles. *Resource and Energy Economics* 31(3), 221–238.

Beck, M.J., Rose, J.M., Hensher, D.A., 2013. Environmental attitudes and emissions charging: An example of policy implications for vehicle choice. *Transportation Research Part A* 50, 171-182.

Brownstone, D., Bunch, D.S., Train, K., 2000. Joint mixed logit models of stated and revealed preferences for alternative-fuel vehicles. *Transportation Research Part B: Methodological* 34 (5), 315–338.

Caulfield, B., Farrell, S., McMahon, B., 2010. Examining individuals' preferences for hybrid electric and alternatively fuelled vehicles. *Transport Policy* 17 (6), 381–387.

3. ARE DRIVERS OF LARGER PRIVATE CARS LESS ENVIRONMENTALLY SENSITIVE? EVIDENCE FROM SPAIN

Choo, S., Mokhtarian, P.L., 2004. What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice, *Transportation Research Part A* 38, 201-222.

Chua, W.Y., Lee, A., Sadeque, S., 2010. Why do people buy hybrid cars?, in *Proceedings of Social Marketing Forum*, University of Western Australia, Perth, Western Australia, Edith Cowan University, Churchlands, W.A., 1-13.

Daly, A., Hess, S., Train, K., 2012. Assuring finite moments for willingness to pay in random coefficient models. *Transportation* 39, 19-31.

Dirección General de Tráfico (DGT), 2013. Censo de conductores por sexo y edad – 2013. <http://www.dgt.es/es/la-dgt/> (assessed 20.07.2016).

Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels or other renewable fuels for transport. *Official Journal of the European Union* 17.05.2003 P.

Erdem, C., Sentürk, I., Simsek, T., 2010. Identifying the factors affecting the willingness to pay for fuel-efficient vehicles in Turkey: A case of hybrids. *Energy Policy* 38 (6), 3038–3043.

European Parliament and Council, 2007a. Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information. <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007R0715> (assessed 15.07.16).

European Parliament and Council, 2007b. Proposal for a Regulation of the European Parliament and of the Council setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles. <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52007PC0856> (assessed 15.07.16).

Eurostat, 2016. Unemployment statistics. http://ec.europa.eu/eurostat/statistics-explained/index.php/Unemployment_statistics (assessed 26.12.16).

Hackbarth, A., Madlener, R., 2012. Consumer Preferences for Alternative Fuel Vehicles: A Discrete Choice Analysis. FCN Working Paper No. 20/2011.

Hackbarth, A., Madlener, R., 2013. Consumer preferences for alternative fuel vehicles: A discrete choice analysis. *Transportation Research Part D: Transport and Environment* 25, 5-17.

Hackbarth, A., Madlener, R., 2016. Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany. *Transportation Research Part A: Policy and Practice* 85, 89–111.

Hadley, S.W., Tsvetkova, A.A., 2009. Potential Impacts of Plug-in Hybrid Electric Vehicles on Regional Power Generation. *The Electricity Journal* 22 (10), 56–68.

Hausman, J.A., 1978. Specification test in econometrics. *Econometrica*. 46: 1251-1271.

Heffner, R.R., Kurani, K.S., Turrentine, T.S., 2007. Symbolism in California's early market for hybrid electric vehicles. *Transportation Research Part D: Transport and Environment* 12 (6), 396-413.

Hensher, D.A., Greene, W.G., 2001. Choosing between conventional, electric and LPG/CNG vehicles in single-vehicle households in Hensher, D.A. (ed) *The Leading Edge of Travel Behaviour Research*, Pergamon Press, Oxford, 725-750.

Hensher, D.A., Li, Z., 2010. Accounting for differences in modelled estimates of RP, SP and RP/SP direct petrol price elasticities for car mode choice: A warning. *Transport Policy* 17 (3), 191–195.

3. ARE DRIVERS OF LARGER PRIVATE CARS LESS ENVIRONMENTALLY SENSITIVE? EVIDENCE FROM SPAIN

Hensher, D.A., Rose, J.M., Greene, W.H., 2015. Applied choice analysis. Second edition, Cambridge University Press.

Hess, S., Fowler, M., Adler, T., Bahreinian, A., 2012. A joint model for vehicle type and fuel type choice: evidence from a cross-nested logit study. *Transportation* 39 (3), 593–625.

Hidrué, M.K., Parsons, G.R., Kempton, W., Gardner, M.P., 2011. Willingness to pay for electric vehicles and their attributes. *Resource and Energy Economics* 33 (3), 686–705.

Horne, M., Jaccard, M., Tiedemann, K., 2005. Improving behavioral realism in hybrid energy–economy models using discrete choice studies of personal transportation decisions. *Energy Econ.* 27, 59–77.

International Energy Agency, 2015. World CO₂ emissions from fuel combustion. <https://www.iea.org/publications/freepublications/publication/CO2EmissionsFromFuelCombustionHighlights2015.pdf> (assessed 15.07.16).

Head of state, 2007. Ley 34/2007 BOE-A-2007-19744. https://www.boe.es/diario_boe/txt.php?id=BOE-A-2007-19744 (assessed 15.07.16).

Kahn, M.E., 2007. Do greens drive Hummers or hybrids? Environmental ideology as a determinant of consumer choice. *Journal of Environmental Economics and Management* 54, 129–145.

Krupa, J.S., Rizzo, D.M., Eppstein, M.J., Brad Lanute, D., Gaalema, D.E., Lakkaraju, K., Warrender C.E., 2014. Analysis of a consumer survey on plug-in hybrid electric vehicles. *Transportation Research Part A: Policy and Practice* 64, 14-31.

Lancaster K., 1966. A new approach to consumer theory. *The Journal of Political Economy* 74, 132-57.

Mau, P., Eyzaguirre, J., Jaccard, M., Collins-Dodd, C., Tiedemann, K., 2008. The 'neighbor effect': simulating dynamics in consumer preferences for new vehicle technologies. *Ecol. Econ.* 68, 504–516.

McFadden, D., Train, K., 2000. Mixed MNL Models for Discrete Response. *Journal of Applied Econometrics* 15 (5), 447-470.

Ministerio de Economía, 2001. Real Decreto 785/2001. BOE-A-2001-13172. https://www.boe.es/diario_boe/txt.php?id=BOE-A-2001-13172 (assessed 15.07.16).

Potoglou, D., Kanaroglou, P.S., 2007. Household demand and willingness to pay for clean vehicles. *Transportation Research Part D* 12, 264–274.

Qian, L., Soopramanien, D., 2011. Heterogeneous consumer preferences for alternative fuel cars in China. *Transportation Research Part D* 16, 607-613.

Revelt, D., Train, K., 1998. Mixed logit with repeated choices: households' choices of appliance efficiency level. *Review of Economics and Statistics* 80, 1-11.

Shin, J., Bhat, C.R., You, D., Garikapati, V.M., Pendyala, R.M., 2015. Consumer preferences and willingness to pay for advanced vehicle technology options and fuel types. *Transportation Research Part C: Emerging Technologies* 60, 511–524.

Street, D., Burgess, L., 2007. *The construction of optimal stated choice experiments*. New Jersey: John Wiley and Sons Inc.

Thatchenkery, S.M., Beresteanu, A., 2008. *Determinants of Automobile Demand and Implications for Hybrid-Electric Market Penetration*. Honors thesis submitted in partial fulfilment of the requirements for Graduation with Distinction in Economics in Trinity College of Duke University.

Train, K. 2003. *Discrete Choice Methods with Simulation*. Cambridge: Cambridge University Press.

Train, Kenneth E., 2009. *Discrete Choice Models with Simulation*. New York: Cambridge University Press (2), 77-82.

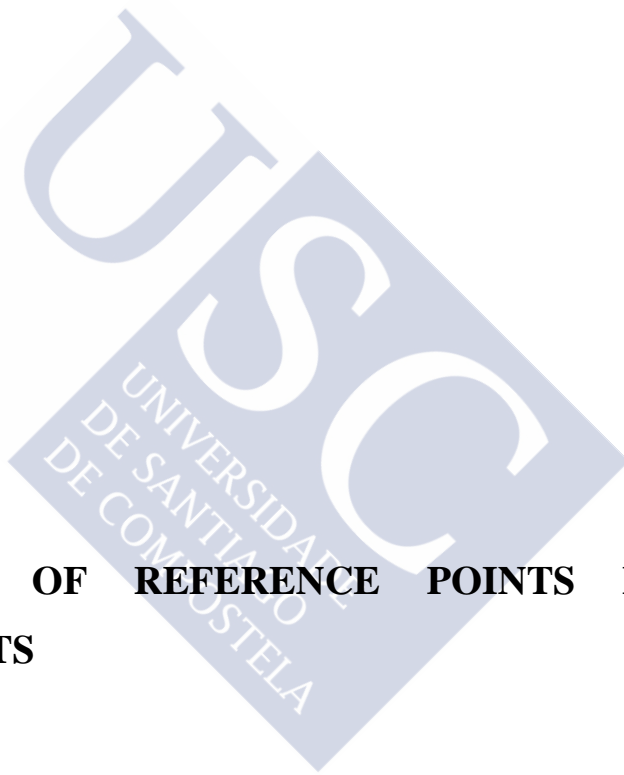
Ziegler, Andreas. 2012. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. *Transportation Research Part A: Policy and Practice* 46 (8), 1372-1385.





CHAPTER 4

**THE ROLE OF REFERENCE POINTS IN CHOICE
EXPERIMENTS**





4. THE ROLE OF REFERENCE POINTS IN CHOICE EXPERIMENTS

Abstract

The effect of a reference point on consumer choice decisions is often ignored when analyzing preferences. This reference point may be crucial for understanding choices. In order to show the importance of considering a reference point when assessing preferences, an application is carried out in the context of discrete choice experiments (DCEs) for hybrid electric vehicles (HEVs). The novelty of this application relies on the use of individually specified reference points according to elicited data. Three models considering three different potential reference points were estimated and compared to a traditional no-reference model. The results demonstrate that choices are affected by reference points. Furthermore, in the current dataset, the results show that vehicle preferences are strongly based on drivers' current vehicle (status quo). The findings suggest that not considering the reference point may reduce the ability of DCEs to explain actual preferences.

4.1 INTRODUCTION

Consumers often face decisions where they have to choose between several options. The question at hand is how they make these types of decisions. Do they assess all of the alternatives and choose the best one, independently of any reference alternative? Or do they choose an alternative that presents an improvement with respect to a given default option?

Prospect theory and cumulative prospect theory provide answers to these questions (Bleichrodt, 2009; Kahneman and Tversky, 1979; Koszegi and Rabin, 2006; Tversky and Kahneman, 1991). Prospect theory generally stipulates that in situations of uncertainty,

behavior is guided by a reference point. Specifically, it states that preferences are more sensitive to disadvantages than advantages, referring to this type of behavior as 'loss aversion'. Prospect theory or some of its features have been tested and supported in several studies, including healthcare programs (Neuman and Neuman, 2008), environmental protection programs (Glenk, 2011; Lanz et al., 2009), brand choices (Hardie et al., 1993), and trip choices (De Borger and Fosgerau, 2008; Hess et al., 2008; Hjorth and Fosgerau, 2009). In addition, some authors have validated prospect theory in the case of the experimental behavior of inexperienced subjects (List, 2004).

Reference dependence is the main cornerstone of prospect theory, given that utilities are defined around the reference point. Therefore, it is vital for researchers to identify and take into account the appropriate reference point that individuals consider when making a choice.

The present empirical study shows that replacing the common no-choice option often included in discrete choice experiments (DCEs) by an individual reference point would improve preferences prediction. The DCE is applied to vehicle choices, and focuses on the valuation of improvement included in alternative fuel vehicles (AFV). This application seeks to identify the most accurate reference point considered by drivers when buying a new vehicle, especially in the context of a discrete choice experiment (DCE). In particular, we explore three different possible reference points: the current endowment (Barton and Bergland 2010; Meyerhoff and Liebe, 2009) or actual status quo (current vehicle), the minimum requirements (Wang and Johnson, 2012) established for the new vehicle (MR), and the goal (Heath et al., 1999) or most desirable type of new vehicle (G). We find that not considering the reference point may lead to biased predictions. Furthermore, the results show that drivers' preferences are formed around the drivers' current vehicle (current endowment or drivers' status quo).

This article is structured as follows: the first section presents a review of the related literature; this is followed by a description of the survey implementation and the DCE design. The next section is a description of the sample used, and the empirical models. The final section presents the results, concluding with some remarks and implications of the findings.

4.2 LITERATURE REVIEW

DCEs mostly include a status quo alternative in order to mimic choice situations as closely as possible (Carson et al., 1994), to improve market share predictions and welfare estimates (Bateman et al. 2002; Hensher et al., 2005), or to avoid forcing people to make choices that they may not like (Batsell and Louviere 1991). The election of the status quo option may reflect preferences for the current situation (Lanz and Provins, 2012), or simply the willingness to avoid complex choices (similar alternatives) in order to reduce mental and emotional efforts (Beshears et al. 2008), or to avoid possible regrets (Samuelson and Zeckhauser, 1988), or protesting (Meyerhoff and Liebe, 2009), while continuing checking for the best option (Dhar, 1997). Oehlmann et al. (2017) found that the election of the status quo increases with the number of choice tasks, the number of attribute levels, and the degree of similarity between alternatives; whereas they showed that the number of alternatives negatively influences the choice of the status quo option.

The opt-out option, when included in DCEs, is generally defined as a non-described “neither option” or a described status quo such as the current situation (Adamowicz et al. 1998; Scarpa et al., 2005). The current situation is most commonly included in DCEs as a common constant alternative for all participants (Barton and Bergland 2010; Meyerhoff and Liebe, 2009). However, the existence of differences between respondents’ specific reference alternatives and this assumed common profile will lead to biases in welfare measures (Kataria et al., 2012). Therefore, considering respondent-specific reference options is preferred to a common profile (Rose et al., 2008; Barton and Bergland, 2010).

In addition to the current endowment, there are a wide variety of interpretations of the reference point in the existing literature, identifying it with goals (Heath et al., 1999), aspirations (Hoffmann et al., 2013), expectations (Bartling et al., 2015; Banerji and Gupta, 2014), and past acquisitions (Baker et al., 2012), among others. Several studies (Koop and Johnson, 2012; Stommel, 2013; Wang and Johnson, 2012) have reported that consumers simultaneously combine multiple reference points (Wang and Johnson, 2012). Wang and Johnson (2012) concluded that consumers seek to achieve a goal that is better than their current situation, and which exceeds certain minimum requirements.

The following empirical analysis is applied to vehicle choices and tests the performance of the three different definitions of the status quo, considering the reference point as the current vehicle, the minimum standards for an acceptable vehicle, and the most desirable (goal or aspirational) vehicle. Oehlmann et al. (2017) showed that welfare estimates depend considerably on the choice design. The following analysis focuses on the assessment of preferences for hybrid electric vehicles (HEV), assessing the impact of vehicle attributes, and the role of socio-demographic variables on choice decisions, considering the existence of various potential reference points. In addition, this work explores the previous phenomenon focusing on particular vehicle characteristics. This analysis focuses on both private and quasi-public attributes, contrary to most of the existing literature that mainly focuses on private attributes. Thus, the present work contributes to research that seeks to understand the nature of choices, especially in the context of DCE, where a given scenario (or status quo) is generally included and potentially understood in different ways. However, most of the literature deals with the opt-out (or status quo) option in a similar way, the most popular of which is the identification of this choice with a zero utility level.

4.3 SURVEY IMPLEMENTATION

An online survey was addressed to a representative sample of adult drivers. This survey was administered in July 2013 to a total of 878 drivers who expressed their desire to purchase a small or medium-sized vehicle in the future. The survey was designed so that it allowed for collecting detailed information about the drivers' actual vehicles, driving and buying habits, environmental attitudes and behavior, HEV perceptions, future vehicle buying intentions in terms of the size and type of vehicle, and their socio-demographic characteristics. The drivers' marginal valuations of these attributes were elicited with DCEs. Part of the information collected in the survey was used to identify the three possible reference points that may affect vehicle choices. In particular, the survey included questions that precisely identified the current vehicle, the minimum desirable characteristics of the new vehicle, and the characteristics of the most desirable vehicle.

4.3.1 EXPERIMENTAL DESIGN AND DCES

DCEs are stated preference approaches based on the assumptions of rationality and utility maximization of consumer choice, according to Lancaster's theory (Lancaster, 1966). They consist of presenting drivers with several vehicle alternatives, described in terms of attributes and their levels (Louviere et al., 2000). For each choice occasion, drivers are asked to choose their preferred vehicle. The driver is assumed to choose a vehicle that provides the maximum utility. The utility derived from choosing a vehicle is assumed to be equal to the sum of the marginal utilities associated with its attributes (Lancaster, 1966). DCE has already been used in several vehicle choice studies (Potoglou and Kanaroglou, 2007; Achtnicht, 2012; Ahn et al., 2008).

Taking into account existing literature on preferences for AFVs (Potoglou and Kanaroglou, 2007) and the fact that HEVs overcome the battery problems of electric vehicles, five vehicle attributes were used in the experiment. These were vehicle type, purchase price, fuel consumption, carbon dioxide (CO₂) emissions, and the adaptation to biofuel. In the previous literature, price and fuel consumption have been found to be very significant when representing the economic dimension of vehicle choices (Adler et al., 2003). CO₂ emissions are often used in studies to express the level of vehicle pollution (Potoglou and Kanaroglou, 2007).

The attribute levels were defined according to the information obtained from vehicle suppliers in the Spanish market concerning small to mid-sized vehicles and previous studies (Achtnicht, 2012; Ziegler, 2012). Regarding the range of the price attribute, the first selected level was the average price of a new vehicle in the Spanish market in 2012 (€16,000), and then two other levels were considered around this average price: a lower price (€12,000) and a higher one (€20,000), respectively. These limits are set taking into account small-medium size vehicles, as well as the reduction of the purchasing power of Spaniards caused by the current economic crisis and the fact that in recent years the highest-selling vehicles in Spain were priced below €20,000. Regarding fuel consumption, its levels have been displayed to drivers in terms of euros spent per 100 kilometer, as has been done in several recent studies (Achtnicht, 2012; Ziegler, 2012). Given the interest in small and medium vehicles and

considering previous studies (Achtnicht, 2012; Ziegler, 2012), a total of two levels were considered: €5 (efficient level) and €7 (inefficient level) per 100 kilometers. Similarly, the levels of CO₂ emissions were displayed to drivers in terms of grams emitted per kilometer, as has been done in recent studies (Achtnicht, 2012; Ziegler, 2012). Following previous studies (Achtnicht, 2012; Ziegler, 2012), an efficient and inefficient level (with 100gr per kilometer and 150gr per kilometer, respectively) were included. With regard to biofuel adaptation, it was considered this flex option in a vehicle as a dichotomous variable.

Both the SPSS orthogonal design and Street and Burgess' (2007) procedure based on the D-efficiency value (vector of differences = 12111; design efficiency of 98%) were used to combine the five attributes and their levels. This combination generated a total of 8 choice sets. It was allowed all attributes with their corresponding levels to be combined across conventional or HEVs. In the survey, each driver was confronted with a total of 8 choice cards. In each card, drivers were asked to select their preferred option out of two vehicle alternatives (HEV vs. conventional) and the no choice option (status quo). Figure 4.1 shows an example of a choice card.

Figure 4.1 Choice experiment question and Card example

Section: Discrete choice experiment			
Imagine taking the decision to purchase a new vehicle. Here are several options, A and B, for typical vehicles with different features that are currently sold in the automotive market. Please select the alternative car (car A, car B, neither A or B) you will buy. We present you several choices to select between various cars shown in each set.			
	Conventional car	HEV	Status quo
Price (€).	€16,000	€20,000	Neither A or B
Fuel consumption (€ per 100km).	€7/100km.	€5/100km.	
Grams of CO ₂ emitted per 1km.	150g/km.	100g/km.	
Biofuel adaptation	No	Yes	
I choose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

In terms of the distributions followed by the considered attributes, the PRICE attribute was assumed to be log-normally distributed (to make the parameter to be always negative), being introduced in the model as a continuous variable. Two effect coding variables were defined for the fuel consumption (SAVING-FUEL) and for CO₂ emissions (ABATEMENT-CO₂) of the vehicles. Both variables are assumed to be log-normally distributed. The log-normally distribution was chosen in order to model positive preferences for these attributes (Achtnicht, 2012; Daziano and Achtnicht, 2014; Nixon and Saphores, 2011). It was also specified the BIOFUEL variable to be effect coding. Several distributions were tested for this

variable; however, their corresponding standard deviations were not statistically significant. Therefore, the parameter of the BIOFUEL variable was specified to be nonrandom. Moreover, two dichotomous specific constants called ASC_c and ASC_h were included, denoting the election of conventional and HEVs, respectively. Both constants were defined to be random and normally distributed, allowing preferences to be positive or negative for both vehicle types.

4.4 DATA

The basic socio-demographic characteristics of the drivers are shown in Table 4.1. The mean age of the sample is 46 years. Fifty-one percent of the drivers are male, while forty-six percent have university studies. While a fifth of the drivers are unemployed, the vast majority (seventy five percent) are members of households which earn a monthly income of more than €1,200. About ninety two percent of the drivers currently own a vehicle. Finally, the average weekly driving frequency in the sample is of four days. Considering the age and driving frequency, the sample was representative of average Spanish drivers (44-year-old men who drive 5 days per week, Spanish Observatory of Drivers, 2014).

Table 4.1 Some descriptive statistics

Variables	Description	Mean	Std. Dev
MALE (dummy)	1 for male, 0 for otherwise.	.513	.499
AGE (Continuous)	Age of the respondents.	45.972	13.546
LHINC (dummy)	1 for monthly income under €1200 and 0 otherwise.	.246	.431
UNIV (dummy)	1 for respondent with university studies, 0 for otherwise.	.457	.498
KNOWLEDGE (dummy)	Individual who know hybrid car owners.	.276	.447
IMAGE (dummy)	1 if “social image” is qualified as important or very important (score>3) and 0 otherwise.	.244	.429

Table 4.2 presents the average of the driver status quo scenarios considered under the different reference points. The average price of the drivers’ current vehicle was €18,609.23 (Std. Dev = 4,075.38). This figure is higher than the average price of new vehicles purchased in Spain in 2013 (around €16,000). The elicited average fuel consumption of the drivers’ current vehicle was €3.195 (Std.Dev=2.885) per 100 km. The drivers’ current vehicles were

utilitarian (34.35%), compact (25.42%), sedan (24.06%), wagon (2.59€), minivan (8.39€), SUV (3.08%), sports (1.48%), and cabriolet (0.62%). Based on the model and the age of the drivers' current vehicle, it has been possible to estimate the average current vehicle emissions being around 167 grams per 1 km. (Std. Dev = 35.436).

Table 4.2 The average of the individual status quo scenarios considered under the different reference points

	Actual choice (AC)	Minimum requirements (MR)	Goal (G)
PRICE (€)	18,609.23 (4,075.38)	14,355.22 (4,006.108)	16,359.81 (4,867.64)
FUEL CONSUMPTION (€/100KM)	3.195 (2.885)	5.670 (.857)	6.508 (1.074)
CO2 EMISSIONS (g/KM)	167 (35.436)	101.548 (22.550)	.

(): Standard deviation.

4.5 DISCRETE CHOICE MODELING

For this analysis, random parameter logit (RPL) models have been used to relax the IIA assumption of a multinomial logit (MNL) allowing for heterogeneous tastes, unrestricted substitution patterns, and correlation in unobserved factors over time (Hensher et al., 2015; Train, 2009). To assess the validity of this IIA assumption in this analysis, the Hausman test has been applied and it was found that this IIA assumption is problematic⁹. The RPL models are estimated using standard Halton sequences draws with 2000 replications (Hensher et al., 2005). First, a traditional no reference dependent (NR) model is estimated, where the attributes of the status quo option have been coded as zeros (Table 4.3). This model was employed as the baseline model of the utility-maximization framework.

⁹ [Omitted alternative is the regular vehicle: Chi-squared (5) =156.808; omitted alternative is the HEV: Chi-squared (5) =160.883; the 99%; critical value: Chi-squared (5) = 15,086].

Table 4.3 Car specific variables in the traditional no reference (NR) model

VARIABLE	=	CODING
PRICE	=	1.2 low level.
		1.6 medium level.
		2.0 high level.
		0 Status quo.
SAVING_FUEL	=	+1 if car consumes €5 per 100 kilometers.
		-1 if car consumes €7 per 100 kilometers.
		0 Status quo.
ABATEMENT_CO2	=	+1 if car emits 100 grams of CO ₂ per 1 kilometer.
		-1 if car emits 150 grams of CO ₂ per 1 kilometer.
		0 Status quo.
BIOFUEL	=	+1 if car is adapted to run with biofuels.
		-1 if car is not adapted to run with biofuels.
		0 Status quo.
ASC _c		1 if car is conventional.
		0 otherwise.
ASC _h	=	1 if car is HEV.
		0 otherwise.

Three different reference dependent models have been estimated based on the three previously detailed reference points, comparing them to the traditional model with no reference point (NR). The results of this comparison may help to identify whether a reference point model performs empirically better. The three estimated reference dependent models are: a) Actual choice (AC)- reference dependent model where drivers' current main vehicle is considered as a reference point; b) Minimum requirements (MR)- reference dependent model, where accepted (MR) attributes for the future vehicle were taken as a reference point; and c) Goal (G) reference dependent model- where the desired attributes of drivers' future vehicle served as reference. It was assumed that PRICE, SAVING_FUEL and ABATEMENT_CO2 are log-normally distributed, while BIOFUEL is nonrandom parameter. Finally, ASC_c, and ASC_h are normally distributed as in the traditional no reference (NR) model.

4.6 RESULTS AND DISCUSSION

The results of the RPL models are shown in Table 4.4. Column 1 in Table 4.4 shows the results of the traditional no reference point (NR) model. Columns 2, 3 and 4 in Table 4.4 summarize the results of the three reference models: the Actual choice (AC) reference dependent model, the Minimum requirements (MR) reference dependent model, and the Goal (G) reference dependent model, respectively.

All estimated models provide somewhat similar results. Specifically, the effects of PRICE, SAVING_FUEL, ABATEMENT_CO2 and BIOFUEL have the expected signs and are statistically significant in all the estimated models. The exceptions are the two alternative specific constants, which are negative in the actual choice (AC) reference dependent model, but positive in the rest of the models. Moreover, the order of importance of the attributes is maintained across the different models, with the effect of the price variable being the greatest, and that of BIOFUEL the smallest. According to the Akaike information criterion (AIC), and the Bayesian information criterion (BIC), the model with the best overall goodness of fit is the actual choice (AC)-based reference dependent model. This result implies that drivers evaluate vehicle alternatives thinking about their current vehicles attributes (reference level), providing evidence of an endowment effect in the valuation exercise. Although the average age of the drivers' current vehicle is about 8 years (73.47% of the drivers' current vehicles were purchased as new vehicles), the effect of this reference point in the drivers' vehicle choices under the DCE is strong. The fact that the reference point influences vehicle choices has important implications on programs launched for promoting HEV (advertising, financial help, etc.), given that it reveals a certain anchoring in purchasing behavior.

In order to facilitate the presentation of the current results, the actual choice (AC)-based reference dependent model shown in column 2 of Table 4.4 is compared to the traditional non-reference dependent (NR) model shown in column 1 of the same table.

The estimated actual choice (AC)-based reference dependent model is statistically significant overall, and has a better statistical fit than the baseline model ($\chi^2(11) = 2,927.778$ and a p-value of 0). All the mean coefficients of the random and nonrandom parameters are statistically significant and present the expected signs.

Table 4.4 Results of estimated random parameter logit models

	NR model	AC model	MR model	G model	Extended AC model
Parameters in utility functions					
LOG(-PRICE)	1.213*** (.028)	.517*** (.054)	.658*** (.037)	.573*** (.044)	.505*** (.057)
LOG(SAVING_FUEL)	-1.256*** (.116)	-1.746*** (.215)	-1.154*** (.114)	-1.287*** (.152)	-1.732*** (.216)
LOG(ABATEMENT_CO2)	-1.505*** (.154)	-1.793*** (.219)	-2.306*** (.300)	-4.235*** (.062)	-1.804*** (.225)
BIOFUEL	.158*** (.021)	.256*** (.046)	.248*** (.044)	.186*** (.044)	.248*** (.046)
ASC _c	5.278*** (.117)	-1.396*** (.074)	.934*** (.075)	2.662*** (.115)	-1.376*** (.250)
ASC _h	6.035*** (.114)	-.727*** (.066)	1.549*** (.068)	3.275*** (.112)	-.957*** (.219)
Standard deviations of random parameters					
LSPRICE	.452*** (.018)	1.083*** (.032)	.705*** (.041)	.780*** (.041)	1.084*** (.034)
LSSAVING_FUEL	1.003*** (.100)	1.321*** (.133)	1.055*** (.072)	1.185*** (.107)	1.311*** (.138)
LSABATEMENT_CO2	1.128*** (.111)	1.653*** (.117)	1.553*** (.132)	.800*** (.029)	1.687*** (.119)
NSASC _c	1.349*** (.066)	1.341*** (.063)	1.367*** (.054)	.793*** (.049)	1.278*** (.064)
NSASC _h	.134 (.458)	1.256*** (.059)	1.259*** (.065)	.376*** (.091)	1.191*** (.061)
Heterogeneity in parameter means					
ASC _c * MALE					.786*** (.127)
ASC _c * AGE					-.016*** (.004)
ASC _c * LHINC					-.157 (.143)
ASC _c * UNIV					.321*** (.124)
ASC _c * KNOWLEDGE					.372*** (.107)
ASC _c * IMAGE					.456*** (.138)
ASC _h * MALE					.695*** (.125)
ASC _h * AGE					-.009** (.004)
ASC _h * LHINC					-.283** (.133)
ASC _h * UNIV					.279** (.118)
ASC _h * KNOWLEDGE					.366*** (.103)
ASC _h * IMAGE					.577*** (.128)

Note: Before the model estimation, the sign of price (expected to be negative) had been inverted in order to overcome convergence problems; ***, **, * ==> Significance at 1%, 5%, 10% level; () ==> Standard Error.

Table 4.4 Results of estimated random parameter logit models (continued)

	NR model	AC model	MR model	G model	Extended AC Model
Goodness of fit					
N	7,000	5,995	6,448	6,440	5,995
GROUPS	875	875	875	875	875
NB. OBSRVS./GROUP	8	8	8	8	8
LL FUNCTION	-5,461.457	-5,122.291	-5,638.309	-5,230.007	-5,077.931
K	11	11	11	11	23
CHI SQUARED [K]	4,457.656	2,927.778	2,891.084	3,690.110	3,016.498
Significance	.000	.000	.000	.000	.000
R-SQRD	.289	.222	.204	.261	.229
R-SQRD ADJUSTED	.289	.222	.203	.260	.227
AIC	10,944.9	10,266.6	11,298.6	10,482.0	10,201.9
BIC	11,020,3	10,340.3	11,373.1	10,556.5	10,355,9
REPLICATIONS	2,000	2,000	2,000	2,000	2,000
SIMULATION	Halton	Halton	Halton	Halton	Halton

N==> Number of observations; LL==> Log likelihood function; LRT==> Log-likelihood ratio; K==> Number of factors; R-SQRD==> Coefficient of determination R squared; R-SQRD ADJUSTED==> Adjusted R-squared ;AIC==> Akaike information criterion; BIC==> Bayesian information criterion.

In order to facilitate the interpretation of the results, the mean and the standard deviation of the coefficients are calculated converting the log coefficients (as shown in Table 4.5). The effect of the price variable is negative, as expected. The effect of energy efficiency (SAVING_FUEL) on drivers' utility is positive, showing that in *ceteris paribus* conditions, drivers prefer more energy efficient vehicles. Similarly, the fact that a vehicle is environmentally efficient (ABATEMENT_CO2), other features being equal, yields a positive effect on drivers' utility. A vehicle adaptable to run with biofuels (BIOFUEL) also has a positive impact on drivers' utility. Finally, the choice-specific constants are significant and negative, indicating that drivers prefer staying with their current vehicles than choosing a new conventional model or HEVs. However, the disutility provided by conventional vehicles is twice as large than that of HEVs, and this difference is statistically significant ($\chi^2(1) = .668$; $P\text{-value} = .000$). Therefore, policies aimed at promoting the adoption of new HEV would be likely to become more successful than those promoting regular vehicles.

Table 4.5 Converting the estimated log terms to the original parameters

Parameters		NR	AC	MR	G	Extended AC
		model	model	model	model	model
PRICE	Mean	-3.729*** (.115)	-3.019*** (.095)	-2.477*** (.090)	-2.406*** (.090)	-2.985*** (.098)
	Std. Dev.	1.778*** (.113)	4.514*** (.229)	1.989*** (.186)	2.206*** (.192)	4.469*** (.232)
	Median	-3.366*** (.095)	-1.678*** (.091)	-1.932*** (.072)	-1.774*** (.078)	-1.658*** (.095)
SAVING_FUEL	Mean	.470*** (.096)	.417*** (.038)	.550*** (.029)	.556*** (.151)	.418*** (.041)
	Std. Dev.	.620*** (.222)	.907*** (.196)	.786*** (.077)	.976*** (.427)	.896*** (.208)
	Median	.284*** (.033)	.174*** (.037)	.315*** (.036)	.275*** (.041)	.176*** (.038)
ABATEMENT_CO2	Mean	.419*** (.034)	.652** (.266)	.332** (.167)	.019*** (.0008)	.683** (.288)
	Std. Dev.	.672*** (.125)	2.474 (1.518)	1.061 (.774)	.018*** (.0005)	2.752 (1.748)
	Median	.221*** (.034)	.166*** (.036)	.099*** (.029)	.014*** (.0009)	.164*** (.037)

***, **, * ==> Significance at 1%, 5%, 10% level; () ==> Standard Error.

In the actual choice model, the standard deviations of all the random parameters are statistically significant, except that of CO₂ emissions (ABATEMENT-CO₂), reflecting the presence of heterogeneity in preferences around the sample for the attributes PRICE, SAVING-FUEL, and the respective constants ASC_c and ASC_h.

An extended actual choice (AC) -based reference dependent model has been estimated in order to further understand the sources of the heterogeneity in preferences for conventional vehicles and HEVs. In particular, vehicle specific constants were interacted with some driver socio-demographic characteristics (MALE, AGE, LHINC, UNIV) suspected to explain part of the preference heterogeneity. It is also expected that preferences heterogeneity for vehicle type may result from product knowledge differences. Thus, the alternative specific constants have been interacted with attributes reflecting whether participants know other HEV owners (KNOWLEDGE). Another possible source of vehicle type preference heterogeneity taken into account is a reputational incentive (IMAGE). The estimated results are shown in Table 4.4 (column 5) and Table 4.5. The results show that preferences heterogeneity for conventional vehicles is affected by the gender (MALE), age (AGE), level of education (UNIV), knowledge (KNOWLEDGE), and social prestige motivation (IMAGE) of the driver. In addition, income (LHINC), level of education (UNIV), knowledge (KNOWLEDGE), and social image incentives (IMAGE) are significant to model preferences towards HEVs.

Moreover, older drivers (AGE) are less likely to choose conventional or HEVs compared to the status quo (current vehicle) option. While the election of HEVs seems to decrease between drivers with low income (LHINC), the choice of conventional vehicles seems to be unaffected.

4.7 CONCLUSIONS AND IMPLICATIONS

Although prospect theory improves behavior prediction when compared to expected utility theory, its application in research approaches continues to be quite reduced, especially in stated preference methods, such as DCEs. This empirical study tests to what extent reference points affect drivers' choice decisions in the context of DCEs, and whether replacing the traditional no-choice option often included in DCEs by drivers' reference points improves model performance. In particular, a DCE is conducted where several different possible reference points expected to define this no-choice alternative are considered. The DCE is applied to vehicle choices, and focuses on the valuation of improvement included in HEVs. This paper identifies the reference point considered by decision makers which better fits the choice data when buying a new vehicle. In the DCE, drivers were asked to choose between two new types of vehicles (HEV or conventional vehicles) and the no-choice option. The impact of three different reference points hidden behind the no-choice option is explored, and assessed whether drivers consider vehicle attributes thinking about any of these default options (reference points). The analysis is conducted using RPL models in order to capture heterogeneity in preferences. The results show that drivers' current vehicles are the reference point that best explains future vehicle choices. This means that the opt-out alternative represented by a described status quo option (current vehicle) leads to a better statistical performance of choice models than the no-choice option. The results demonstrate that it is important to account for reference points when eliciting preferences with DCEs. In particular, not considering the effect of a reference point decreases the statistical performance of the empirical models. The results also show that drivers prefer staying with their current vehicles rather than opting for conventional or HEVs. However, they are relatively more likely to select HEVs than conventional vehicles, *ceteris paribus*.

Overall, it was found that the current reference point affects preferences for other alternatives. This may be related to the endowment effect, or simply loss aversion due to the lack of information on the drivers' experience. Future research should be conducted in order to disentangle the potential effects related to loss aversion from the endowment effect.



4.8 REFERENCES

Achtnicht, M., 2012. German car buyers' willingness to pay to reduce CO₂ emissions. *Climatic Change* 113(3-4), 679-697.

Adamowicz, W.L., Boxall, P.C., Williams, M. Louviere, J., 1998. Stated preference approaches for measuring passive use values: choice experiments and contingent valuation, *American Journal of Agricultural Economics* 80, 64–75.

Adler, Thomas Wargelin, Laurie Kostyniuk, Lidia Kavalec, Chris and Gary Occhiuzzo 2003. Incentives for alternative Fuel Vehicles: A Large-Scale Stated Preference Experiment, paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, August 2003.

Ahn, J., Jeong, G., Kim, Y., 2008. A forecast of household ownership and use of alternative fuel vehicles: A multiple discrete-continuous choice approach. *Energy Economics* 30 (5), 2091–2104.

Baker, M., Pan, X., Wurgler, J., 2012. The effect of reference point prices on mergers and acquisitions. *Journal of Financial Economics* 106, 49-71.

Banerji, A., Gupta, N., 2014. Detection, identification, and estimation of loss aversion: Evidence from an auction experiment. *American Economic Journal: Microeconomics* 6 (1), 91-133.

Bartling, B., Brandes, L., Schunk, D., 2015. Expectations as reference points: field evidence from professional soccer. *Management Science* 61, 2646-2661.

Barton, D., Bergland, O., 2010. Valuing irrigation water using a choice experiment: an 'individual status quo' modelling of farm specific water scarcity. *Environment and Development Economics* 15(3), 321-340.

Bateman, I., Carson, R., Day, B., Hanemann, W., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D., Sugden, R., Swanson, J., 2002. *Economic Valuation with Stated Preference Techniques: A Manual*: Edward Elgar Publishing, Cheltenham.

Batsell, R.R., Louviere, J.J., 1991. Experimental analysis of choice. *Marketing Letters* 2,3, 199–214.

Beshears, J., Choi, J.J., Laibson, D., Madrian, B.C., 2008. How are preferences revealed? *Journal of Public Economics* 92, 1787–1794.

Bleichrodt, H., 2009. Reference-dependent expected utility with incomplete preferences. *Journal of Mathematical Psychology* 53, 287–293.

Carson, R.T., Louviere, J.J., Anderson, D., Arabie, P., Bunch, D.S., Hensher, D.A., Johnson, R.M., Kuhfeld, W.F., Steinberg, D., Swait, J., Timmermans, H., Wiley, J.B., 1994. Experimental analysis of choice, *Marketing Letters* 5(4), 351-368.

Daziano, R.A., Achtnicht, M., 2014. Accounting for uncertainty in willingness to pay for environmental benefits. *Energy Economics* 44, 166–177.

De Borger, B., Fosgerau, M., 2008. The trade-off between money and travel time: A test of the theory of reference-dependent preferences. *Journal of Urban Economics* 64, 101–115.

Dhar, R., 1997. Consumer Preference for a No-Choice Option. *Journal of Consumer Research* 24, 215–31.

Glenk, K., 2011. Using local knowledge to model asymmetric preference formation in willingness to pay for environmental services. *Journal of Environmental Management* 92 (3), 531-41.

Hardie, B.G., Johnson, E.J., Fader, P.S., 1993. Modeling loss aversión and reference dependent effects on Brand choice. *Marketing Science* 12 (4), 378-394.

Heath, C., Larrick, R. P., Wu, G., 1999. Goals as reference points. *Cognitive Psychology* 38, 79-109.

Hensher, D. A., Rose, J. M. and Greene, W. H. 2005. *Applied Choice Analysis - A Primer*. Cambridge University Press, New York.

Hensher, D.A., Rose, J.M., Greene, W.H., 2015. *Applied choice analysis*. Second edition, Cambridge University Press.

Hess, S., Rose, J.M., Hensher, D.A., 2008. Asymmetric preference formation in willingness to pay estimates in discrete choice models. *Transportation Research Part E* 44(5), 847–863.

Hjorth, K., Fosgerau, M., 2009. Determinants of the degree of loss aversion. *International Choice Modelling Conference*, Leeds (UK).

Hoffmann, A.O.I., Henry, S.F., Kalogeras, N., 2013. Aspirations as Reference Points: An Experimental Investigation of Risk Behavior over Time. *Theory and Decision* 75, 193-210.

Kahneman, D., Tversky, A., 1979. Prospect theory: An analysis of decisions under risk. *Econometrica* 47, 313–327.

Kataria, M., Bateman, I., Christensen, T., Dubgaard, A., Hasler, B., Hime, S., Ladenburg, J., Levin, G., Martinsen, L., Nissen, C., 2012. Scenario realism and welfare estimates in choice experiments – A nonmarket valuation study on the European water framework directive. *Journal of Environmental Management* 94(1), 25-33.

Koop, G. J., Johnson, J. G., 2012. The use of multiple reference points in risky decision making. *Journal of Behavioral Decision Making* 25, 49 – 62.

Kőszegi, B., Rabin, M., 2006. A model of reference-dependent preferences. *Quarterly Journal of Economics* 121, 1133–1165.

Lancaster K., 1966. A new approach to consumer theory. *The Journal of Political Economy* 74, 132-57.

Lanz, B., Provins, A., Bateman, I., Scarpa, R., Willis, K., Ozdemiroglu, E., 2009. Investigating willingness to pay – willingness to accept asymmetry in choice experiments. *International Choice Modelling Conference, Leeds (UK)*.

Lanz, B., Provins, A., 2012. Do status quo choices reflect preferences? Evidence from a discrete choice experiment in the context of water utilities' investment planning. *CEPE Working Paper No. 87*.

List, J.A., 2004. Neoclassical theory versus prospect theory: Evidence from the marketplace. *Econometrica* 72(2), 615-625.

Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. *Stated Choice Methods: Analysis and Applications*, Cambridge University Press, Cambridge, UK.

Meyerhoff, J., Liebe, U., 2009. Status Quo Effect in Choice Experiments: Empirical Evidence on Attitudes and Choice Task Complexity. *Land Economics* 85 (3), 515–528.

Neuman, E., Neuman, S., 2008. Reference-dependent preferences and loss aversion: A discrete choice experiment in the health-care sector. *Judgment and Decision Making* 3 (2), 162–173.

Nixon, H., Saphores, J.D., 2011. Understanding household preferences for alternative-fuel vehicle technologies. *Mineta Transportation Institute REPORT 10-11*.

Oehlmann, M., Meyerhoff, J., Mariel, P., Weller, P., 2017. Uncovering context-induced status quo effects in choice experiments. *Journal of Environmental Economics and Management* 81, 59–73.

Potoglou, D., Kanaroglou, P. S., 2007. Household demand and willingness to pay for clean vehicles. *Transportation Research Part D: Transport and Environment* 12 (4), 264–274.

Rose, J.M., Bliemer, M.C., Hensher, D.A. Collins, A.T. 2008. Designing efficient stated choice experiments in the presence of reference alternatives. *Transportation Research Part B* 42, 395-406.

Samuelson, W., Zeckhauser, R., 1988. Status quo in decision making, *Journal of Risk and Uncertainty* 1, 7–59.

Scarpa, R., Ferrini, S., Willis, K.G., 2005. Performance of Error Component Models for Status-Quo Affects in Choice Experiments. In *Applications of Simulation Methods in Environmental and Resource Economics*, ed. Scarpa, R. and A. Alberini. Dordrecht, Netherlands: Springer.

Spanish observatory of drivers, 2014. Estudio del conductor español: hábitos en los desplazamientos y viajes en vacaciones. Available at: <http://www.ducit.es/estudios-ducit>.

Stommel, E., 2013. Reference-dependent preferences: A theoretical and experimental investigation of individual reference-point formation. Springer Gabler.

Street, D., Burgess, L., 2007. The construction of optimal stated choice experiments. New Jersey: John Wiley and Sons Inc. <http://crsu.science.uts.edu.au/choice/choice.html>.

Train, Kenneth E., 2009. *Discrete Choice Models with Simulation*. New York: Cambridge University Press (2), 77-82.

Tversky, A., Kahneman, D., 1991. Loss aversion in riskless choice: A reference-dependent model. *The Quarterly Journal of Economics* 5, 1039–1061.

Wang, X. T., Johnson, J. G., 2012. Tri-reference point theory of risky choice. *Journal of Experimental Psychology: General* 141(4), 743-56.

Ziegler, Andreas. 2012. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. *Transportation Research Part A: Policy and Practice* 46 (8), 1372-1385.



ANNEX 4.1 Results of the Multinomial Logit (MNL) Model

	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval
PRICE	-2.056	.055	-36.96	.000	[-2.165 -1.947]
SAVING_FUEL	.281	.017	16.19	.000	[.247 .315]
ABATEMENT_CO2	.255	.017	14.65	.000	[.220 .289]
BIOFUEL	.100	.017	5.87	.000	[.066 .133]
ASC _c	2.980	.084	35.32	.000	[2.814 3.145]
ASC _h	3.402	.086	39.38	.000	[3.233 3.571]
STATISTICS:					
N			7,000		
GROUPS			875		
NB. OBSRVS./GROUP			8		
LL FUNCTION			-6,578.012		
K			6		
R-SQRD			.136		
R-SQRD ADJUSTED			.135		
AIC			13,168.0		
BIC			13,209.1		



III. CONCLUSIONS





III. CONCLUSIONS

III.1 MAIN FINDINGS BY CHAPTER

This dissertation identifies the determinant factors that drive alternative fuel vehicles (AFVs) choice; particularly hybrid electric vehicle (HEVs). Previous literature (Bühne et al., 2015; Hoen and Koetse, 2012; Thiel et al., 2012) has clarified the motives (lack of charging stations, limited range, expensive, slow, etc.) of drivers reluctance towards electrified vehicles, including electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs); however, little is known about the potential of HEVs to become the main future substitute of traditional gasoline and diesel internal combustion engine vehicles. In the present work, preferences for HEV and its attributes have been elicited among 1,016 Spanish drivers. In particular, preferences for price, improvements in energy savings, reductions in environment impacts, and fuel flex ability are assessed based on a structured online discrete choice experiment (DCE). This research is implemented to achieve three main purposes: 1) to test whether HEVs are able to gain market share compared to conventional vehicles in the future; 2) to inform decision makers about the effectiveness of current incentive schemes (*Pive* plan, *Movea* plan, etc.) aiming at encouraging the use of AFVs and to provide improvements for possible future mobility plans; 3) and to provide useful information about how to improve DCEs' predictions of preferences. These proposals led to important and innovative conclusions in order to improve the understanding of vehicle choice process in the context of DCEs.

The first Chapter of this dissertation assesses drivers' preferences and willingness-to-pay (WTP) for HEVs, fuel-flex vehicles, and improvements in certain economic (fuel consumption) and environmental specific vehicle attributes (CO₂ emissions). In particular, the distributions of drivers' WTP for vehicle attributes are estimated based on discrete choice random parameter models (RPLs) where tastes are allowed to vary across drivers and over time including those for price and finite moments for WTPs are assured (Daly et al., 2012). In

this context, several discrete choice models (Daziano and Achtnicht, 2014; Tanaka et al., 2014) have been used to estimate the WTP distributions for AFVs. Nevertheless, consumers' tastes variations for the cost attribute are often ignored (cost parameter is often held fixed which is unrealistic) in order to make the distribution of the WTP to coincide with that of the non-cost parameter. Moreover, this Chapter uses a more flexible RPL to identify the sources of heterogeneity associated with the mean of the vehicle type effect. In particular, it tests whether drivers with stronger preferences towards incentives such as direct subsidies, registration tax exemption, free parking, access to priority lanes, as well as other reputational factors would be more likely to select a HEV or efficient medium vehicle over the status-quo option. Differences in preferences for HEVs are found due to drivers' perceptions of free parking pass and symbolic meanings associated with HEVs such as social image. Thus, decision makers should take into account these differences to customize future mobility plans aimed to increase the demand of HEVs. In line with Hoen and Koetse (2012), we find a wide heterogeneity in preferences, particularly for conventional vehicles, price, fuel consumption, CO₂ emissions and flex-fuel vehicles. Further, contrary to what Liu (2014) found, drivers are not, *ceteris paribus*, willing to pay a premium for HEVs compared to conventional vehicles. However, they are likely to assume additional costs for improvements in vehicles attributes, implying that there is still a lack of knowledge or misunderstandings about the improvements in energy saving and reductions in environment impacts offered by HEVs. In this line, Hoen and Koetse (2012) attributed negative preferences for AFVs to the fact that they are unfamiliar. Under current market conditions, the diffusion of HEVs will continue to rely on much larger subsidies than the existing ones. This explains in part their current low market rate which represents 2.70% of the total vehicles sold in Spain in 2016 (ANFAC, 2017). Thus, promotional campaigns might be used to avoid current misunderstandings about HEVs and therefore increase their demand. Also, starting with facilitating the use of HEVs among collectives such as taxi drivers will make HEVs more popular and drivers more trusting. The idea behind this is that making more apparent HEV in cities would create a new visual impact encouraging more people to want to drive it, and thereby enhance its acceptance and demand. Additionally, findings show special attractions for fuel flex vehicles, implying that the encouragement of production of flexible HEV in the upcoming years would increase drastically its expanse. In addition, the use of less restrictive discrete choice models to assess

preferences increases the model predictive capacity and explanatory power, so it improves the understanding of consumer' real choices in DCEs.

The second Chapter examines driver preferences and their willingness to pay a premium for HEV and its attributes, hereby considering taste variations in the population by using a latent class model (LCM) with 4 distinct driver groups (classes). In particular, it identifies among these 4 different groups of drivers possible heterogeneities in tastes for specific vehicle types and corresponding attributes. Knowing and understanding taste specifications of each driver group will provide a great help to decision-makers concerning the way forward to customize HEV offer and to implement different incentive programs based on taste divergences across drivers. Findings show that taking into account preference heterogeneities through the use of a LCM improves strongly the predictions of the traditional multinomial logit (MNL) model, indicating that preferences of the four groups are different (not homogeneous like assumed by the MNL). Furthermore, the results reveal that HEVs are likely to be preferred by two groups of drivers. More precisely, from the entire sample, 58.9% prefer, *ceteris paribus*, HEVs over conventional vehicles although 15.5% do it in part for reputational incentives. The potential buyers of HEVs are less sensitive to price (Hackbarth and Madlener, 2016), more likely to be female (Abdoolakhan, 2010), image seekers (Chua, 2010), aged (Abdoolakhan, 2010; Hidrue et al., 2011), or with high monthly incomes (Potoglou and Kanaroglou, 2007; Thatchenkery and Beresteanu, 2008). The rest of the sample, although they do not appreciate HEVs compared to conventional vehicles, they value savings positively in fuel consumption or reductions in CO₂ emissions which are two enhancements included in HEVs. Hence, the two pro-HEV groups should be the target for incentive schemes aiming to boost HEV demand in the future. However, the drivers who are not interested about HEVs may be subject to policies to change their vehicle choice decisions in favor of HEVs and thereby contribute to protect the environment. Moreover, the two pro-HEV groups are also the only ones interested in flex-fuel vehicles, implying that enhancing the production of fuel-flex HEV would encourage adoption, and thereby, to contribute significantly to the reduction of the environmental impacts of road transport. Additionally, the LCM results reveal that the sampled population has an average WTP to update a vehicle, from regular to HEV of about €2,476.75 in *ceteris paribus* conditions, an amount similar to that found by Liu (2014), but well below the price markup for most available model of this

technology (Toyota, 2016), so that, at the moment and generally, the spread of HEVs still needs the current public economic support (*PIVE, Movea, ...etc.*). While the not motivated groups to adopt HEVs, *ceteris paribus*, are not eager to assume additional costs to acquire HEVs, the two pro-HEV groups are more likely to pay much more than the average population's WTP. This indicates that there are drivers who do not need or need small economic incentives to adopt HEVs; whereas, some others need more than the current offered subsidies even, they may need a change in perception. Thus, effective decisions aimed at promoting the use of HEVs should be directed in the short term to the potential buyers in order to meet the national and international requirements related to greening road transport process as soon as possible.

The third Chapter analyzes the underlying determinant factors used by drivers when buying new vehicles, emphasizing the dispersions in driver tastes for vehicle type and attributes according to vehicle size. Heterogeneity in preferences for vehicles is assessed among two groups defined according to the size of their next desired vehicle. In particular, a comparison of preferences is carried out across survey drivers who face tradeoffs between small/midsize vehicle's attributes and those who confront the task of choosing between large vehicle's attributes. This chapter tries to answer the following question: Are drivers of larger cars less environmental sensitive? This analysis is justified by the recent interest of many government agencies to promote the production and the use of energy-efficient small vehicles. Findings provide evidence of preferences for small/midsize vehicles over large vehicles and for HEVs over conventional vehicles in *ceteris paribus* conditions. These findings are in line with those found by Caulfield et al. (2010) but unlike those by Hackbarth and Madlener (2012). Furthermore, results reveal that drivers of large vehicles have a pattern of preferences for environment attributes identical to that of drivers of small/midsize vehicles. Moreover, results show that preferences of drivers of small/midsize vehicles are more heterogeneous than those of drivers of large vehicles, implying that environmental policies should be more customized when directed to drivers of small/midsize vehicles. Male prefer HEVs in the case of small/midsize vehicle choice, whereas they are less likely to choose HEVs when they choose between large vehicles. Future drivers of small/midsize vehicle models who consider their social image to be very important when buying a new vehicle are more likely to choose HEVs (not happening with large vehicles). In addition, WTP estimates show that drivers are

not, *ceteris paribus*, willing to pay a premium neither for small/midsize HEVs nor for large HEVs compared to conventional vehicles; however they are likely to pay more for a vehicle with low fuel consumption, low CO₂ emissions, and which is adopted to run with biofuels. In particular, WTP estimates for large vehicle attributes are larger than those estimated for small/midsize vehicle. Thus, findings suggest that drivers would not buy a vehicle just for being hybrid, but they would buy a vehicle if it consumes less, emits little or it is able to run with biofuels. This finding may seem contradictory, but as it turns out, a significant number of respondents does not fully understand HEVs characteristics, although these were previously explained in the survey.

The fourth Chapter tests the reference dependence in preferences and evaluates the importance of defining the reference point when assessing preferences with DCEs. DCEs often included a no-choice option or a reference option defined in different ways (current vehicle, preferred vehicle, etc.) by researchers which leads to determine different estimates. The objective is to find the best way to present and to define this reference point in the case of vehicle choice to improve the predictive ability of the discrete choice models. In particular, three reference RPL models are estimated based on different reference points and compared to a traditional no reference model. Findings demonstrate that empirical models are affected by reference points, and ignoring this effect leads to biased estimates, and thereby it reduces the ability of DCEs to explain real preferences. Furthermore, results show that vehicle preferences are formed around drivers' current vehicle (status quo), implying that there may exist a reference point bias. Thus, public policies need to make HEVs more visible and current less efficient vehicles less attractive and more difficult to maintain through higher taxes, driving restrictions, and others.

III.2 GENERAL CONCLUSIONS

The contribution of road transport to environmental pollution and global warming is very significant, so an effective, rapid and coordinated response is required by public authorities, and manufactures. The way forward starts by the removal or improvement of traditional vehicles and the expansion of AFVs through support schemes directed to the more potential receptors (buyers). Until recently, the environment issues were not so important for public

decision makers, but from now on environment will be a determinant variable to take into account in any future mobility plan. The challenge is not easy and needs many efforts from all parties (drivers, manufacturers, and governments). Previous studies (Bühne et al., 2015; Hoen and Koetse, 2012; Thiel et al., 2012) informed that electrified vehicles (EVs and PHEVs) are more likely to become long-term solutions. However, HEVs and flex fuel vehicles could be good short-term solutions to reduce vehicle emissions and to meet domestic and global requirements. The aim of this dissertation has been to analyze discrete choice preferences and taste variations for vehicle attributes and their influences on the demand of HEVs.

This dissertation contributes to better understand the mechanisms driven vehicle choice decisions and to improve the explanatory power of DCEs. In particular, the carried out analysis focused on a type of AFV (HEV) that is not a drastic change for drivers and very little studied. Moreover, a special attention is given to some behaviors rarely or never addressed in the context of DCEs, including tastes heterogeneity at several levels (individual, group and population), over time or alternatives, over vehicle size, and reference dependence. To achieve this, DCEs and flexible discrete choice models have been employed. This leads to general conclusions that provide useful information to decision makers for future plans and promotion strategies.

Findings suggest that public policies aimed at encouraging the use of HEVs should be customized to driver groups according to their preferences and the characteristics of their current vehicles. In particular, a special attention should be given to the more motivated audience who is likely to make an effort to get this technology. Moreover, given the current conditions, public economic support is needed to adopt HEVs but supporting it with other strategies, including promotions, free parking pass, and more taxes for conventional vehicles among others. This could serve to reduce these public costs and to extend their use. Furthermore, the effect of reference points on choice decisions is crucial for understanding choices, particularly those made in the context of DCEs.

III.3 FUTURE RESEARCH NEEDS

The present research offers a useful guide for decision makers to evaluate the existing politics related to AFVs and to prepare future action plans. Nevertheless, future research can extend the present research in several ways. Overall, our findings have shown that current Spanish policies aimed to encourage the purchase of AFVs are insufficient. Thus, it would be interesting to investigate the effect of more aggressive measures applied in other countries on the market of AFVs in Spain. In this context, the set of measures implemented by Norway to encourage people to opt for EVs have already proved their effectiveness. Precisely, Norway reached the target of 50,000 EVs in 2015 through a mix of public monetary and non-monetary incentives in favor of EVs, including VAT and registration taxes exemption, access to priority lanes, free toll roads, free parking, free travel on ferries, free municipal recharging, reductions in annual driving fee, and exemption from company car tax (Phillips, 2015). The bonus-malus French system was able to reduce the emissions of new registered passenger vehicles by 19g/km in just three years after its introduction (Rubik and Mityorn, 2011). This system not only offers a super-bonus (€10,000) for delivering a diesel vehicle over 10 years-old, a bonus that can reach up to €6,300 for the purchase of new vehicle with low CO₂ emissions, but it also imposes a fine up to €8,000 for the purchase of vehicles with high CO₂ emissions (Rubik and Mityorn, 2011). Furthermore, other restrictive measures (access to the center, surroundings, or to parking) used by some large European cities to deal with the emergency pollution situations could stimulate drivers to opt for AFVs if applied more often (a few days a week). Moreover, after the Volkswagen emissions scandal (dieselgate), the sales of diesel vehicles in Spain have dropped temporarily in favor of gasoline vehicles, HEVs, and EVs (ANFAC, 2017). This shift towards gasoline vehicles could have been diverted in favor of AFVs if the right market incentives were in place. Therefore, future research should look at the combined effect of different instruments (access restrictions, taxes, and fines) and observe the final effect that they may cause on the selection of AFVs.

III.4 REFERENCES

Abdoolakhan, Z., 2010. Acceptance of Alternative Fuel and Hybrid Vehicles in Australia – Results Based on Survey Data, Choice Modelling and Elasticity Estimation. Doctoral thesis, The University of Western Australia, Perth.

Asociación Española de Fabricantes de Automóviles y Camiones (ANFAC), 2017. http://www.anfac.com/estadisticas.action?accion=estad_turismos (accessed 12.01.17).

Bühne, J.A., Gruschwitz, D., Hölscher, J., Klötzke, M., Kugler, U., Schimeczek, C., 2015. *European Transport Research Review* 7, 30.

Caulfield, B., Farrell, S., McMahon, B., 2010. Examining individuals' preferences for hybrid electric and alternatively fuelled vehicles. *Transport Policy* 17 (6), 381–387.

Chua, W.Y., Lee, A., Sadeque, S., 2010, Why do people buy hybrid cars?, in Proceedings of Social Marketing Forum, University of Western Australia, Perth, Western Australia , Edith Cowan University, Churchlands, W.A., pp. 1-13.

Daly, A., Hess, S., Train, K., 2012. Assuring finite moments for willingness to pay in random coefficient models. *Transportation* 39, 19-31.

Daziano, R.A., Achtnicht, M., 2014. Accounting for uncertainty in willingness to pay for environmental benefits. *Energy Economics* 44, 166–177.

Hackbarth, A., Madlener, R., 2012. Consumer Preferences for Alternative Fuel Vehicles: A Discrete Choice Analysis. FCN Working Paper No. 20/2011.

Hackbarth, A., Madlener, R., 2016. Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany. *Transportation Research Part A: Policy and Practice* 85, 89–111.

Hidrue, M.K., Parsons, G.R., Kempton, W., Gardner, M., 2011. Willingness to pay for electric vehicles and their attributes. *Resource and Energy Economics* 33(3), 686-705.

Hoen, A., Koetse, M.J., 2012, A Choice Experiment on AFV Preferences of Private Car Owners in The Netherlands, PBL Working Paper 3, PBL Netherlands Environmental Assessment Agency, Den Haag, The Netherlands.

Liu Y., 2014. Household demand and willingness to pay for hybrid vehicles. *Energy Economics* 44, 191–197.

Phillips, L., 2015. Norway's electric vehicle revolution: Lessons for British Columbia. Pacific Institute for Climate Solutions (PICS), Briefing Note 2015 – 43.

Potoglou, D., Kanaroglou, P.S., 2007. Household demand and willingness to pay for clean vehicles. *Transportation Research Part D* 12(4), 264-274.

Rubik, F., Mityorn, L., 2011. CO2-based Motor Vehicle Tax. Institute for Ecological Economy Research, The SCP-Knowledge Hub: 30 September 2011.

Tanaka, M., Takanori, I., Kayo, M., Lee, F., 2014. Consumers' willingness to pay for alternative fuel vehicles: A comparative discrete choice analysis between the US and Japan. *Transportation Research Part A* 70, 194–209.

Thatchenkery, S.M., Beresteanu, A., 2008. Determinants of automobile demand and implications for hybrid-electric market penetration. Duke University, Durham, North Carolina.

Thiel, C., Alemanno, A., Scarcella, G., Zubaryeva, A., Pasaoglu, G., 2012. Attitude of European car drivers towards electric vehicles: a survey. European Commission, DG JRC, Institute for Energy and Transport, Petten, the Netherlands IPSOS public Affair S.r.l., Milan, Italy.

Toyota, 2016. <http://www.toyota.es/coches/yaris/index.json> (accessed 18.01.2016).




IV. APPENDICES





IV. APPENDICES

III.5 QUESTIONNAIRE FOR DRIVERS OF SMALL OR MIDSIZE VEHICLES




Hola!

La Universidad de Santiago de Compostela está realizando esta encuesta a cerca de su uso de los vehículos y sus preferencias, así como sus opiniones de diversas tecnologías disponibles actualmente en el mercado de la automoción. La encuesta se puede completar en unos 10 minutos.

Su participación es de suma importancia para nosotros. Recuerde que no hay respuestas ni correctas ni incorrectas y que su identidad permanecerá totalmente en el anonimato. Esta encuesta es solo para fines de investigación.

Le damos las gracias por participar!

[Siguinte](#)

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**Cuestionario
Preferencias
sobre
vehículos**

0% 100%

CARACTERÍSTICAS SOCIO-DEMOGRÁFICAS

* ¿Sexo?

 Femenino
 Masculino

* ¿Año de nacimiento?

 Opción

Sólo se pueden introducir números en este campo.

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0%

100%

CARACTERÍSTICAS SOCIO-DEMOGRÁFICAS

* ¿Nivel de formación/estudios?



Seleccione una de las siguientes opciones

- Sin estudios
- Estudios Primarios / EGB/ Bachiller Elemental o similares
- FPI / FPII o similares
- Bachiller Superior / BUP / COU o similares
- Universitarios de Grado Medio o similares
- Universitarios de Grado Superior o similares

* ¿Ocupación?



Seleccione una de las siguientes opciones

- Empleado público
- Autónomo
- Asalariado empresa privada
- Desempleado
- Estudiante
- Labores del hogar
- Jubilado / pensionista
- Otros (Especificar abajo)

Por favor, escriba la justificación de su respuesta aquí:

* ¿Distancia al lugar de su trabajo o estudio? (con respeto al lugar donde vive)



Seleccione una de las siguientes opciones

- Menos de 10km
- Entre 10 y 20 km
- Entre 21 y 30 km
- Entre 31 y 40 km
- Entre 41 y 50 km
- Entre 51 y 60 km
- Entre 61 y 70 km
- Más de 70 km

* ¿Cuántos años lleva usted conduciendo?



Opción

Sólo se pueden introducir números en este campo.

* ¿En promedio, ¿cuántos días a la semana conduce?



Opción

Sólo se pueden introducir números en este campo.

* ¿En un día que conduce, aproximadamente cuántas horas pasa usted conduciendo?



Seleccione una de las siguientes opciones

- Menos de 30 minutos
- 30 minutos - 1 hora
- 1 hora - 2 horas
- 2 horas - 3 horas
- 3 horas - 4 horas
- 4 horas - 5 horas
- Más de 5 horas
- No conduzco nunca

* ¿Ingreso mensual familiar del hogar?



Seleccione una de las siguientes opciones

- Menos de 300 €
- 300 - 600 €
- 600 - 1200 €
- 1.200 - 1800 €
- 1800 - 2400 €
- 2400 - 3000 €
- 3000 - 4000 €
- Más de 4000 €

* ¿Numero de personas totales que viven en su hogar?



Seleccione una de las siguientes opciones

- 1
- 2
- 3
- 4
- 5 o mas

* ¿Cuántas menores de 10 años?



Opción

Sólo se pueden introducir números en este campo.


* ¿Cuántas tienen entre 10 y 18 años?



Opción

Sólo se pueden introducir números en este campo.

*** ¿Nacionalidad?**

 Seleccione una de las siguientes opciones

Española

Extranjera (escribe su país abajo)

Por favor, escriba la justificación de su respuesta aquí:

*** Provincia**



Opción

*** Ciudad/Localidad**



Opción

*** ¿Código Postal?**



Opción

Sólo se pueden introducir números en este campo.

Siguiente



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Introducción

* ¿Cuántos coches hay en su casa actualmente?

 Seleccione una de las siguientes opciones:

- 0
- 1
- 2
- 3 o mas

* ¿Es usted el conductor principal de uno de estos coches?

 Sí

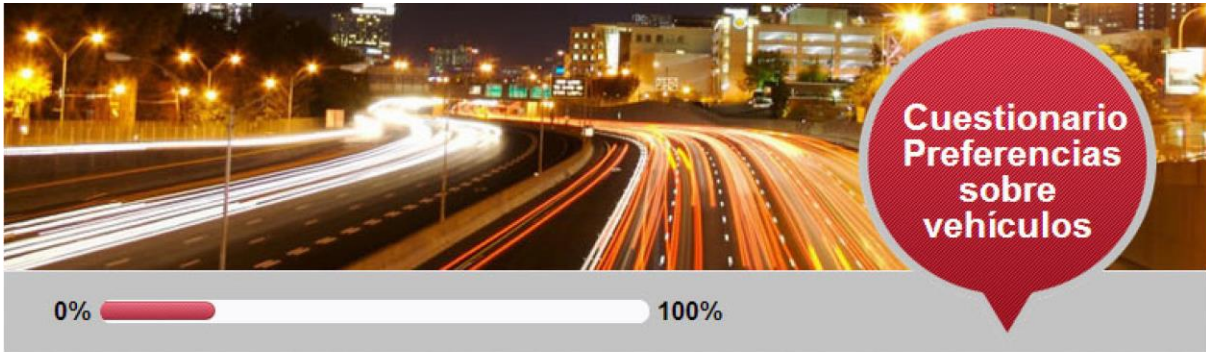
No

En la siguiente sección, le vamos a preguntar sobre las características del coche que conduce habitualmente. En caso de que ud haya respondido "No" en P2, puede completar esta sección refiriéndose al coche más usado de su hogar.

[Siguiente](#)

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I. ACERCA DEL VEHÍCULO QUE CONDUCE PRINCIPALMENTE

* ¿Que vehículo conduce principalmente?



Seleccione una de las siguientes opciones

- Audi
- BMW
- Chevrolet
- Citroën
- Fiat
- Ford
- Honda
- Hyundai
- Iveco
- Mazda
- Mercedes
- Mitsubishi
- Nissan
- Opel
- Peugeot
- Porsche
- Renault
- Seat
- Toyota
- Volkswagen
- Otra (especificar abajo)

Por favor, escriba la justificación de su respuesta aquí:

* ¿Carrocería?



Seleccione una de las siguientes opciones

- Utilitario (Opel Corsa, Seat Ibiza, Renault Clio, ...)
- Compacto (Peugeot 308, Honda Civic, Ford Focus, ...)
- Berlina (Volkswagen Passat, Seat Exeo, Audi A4, ...)
- Ranchera (Audi A4 Avant, BMW Serie 3 Touring, ...)
- Monovolumen (Volkswagen Touran, Renault Espace, ...)
- Todoterreno (Audi Q7, Porsche Cayenne, ...)
- Deportivo (BMW Z4, Audi TT, Porsche Cayman, ...)
- Descapotable (Audi A5 Cabrio, BMW Serie 6 Cabrio, ...)

* ¿En qué condiciones obtuvo el coche que conduce habitualmente?



Seleccione una de las siguientes opciones

- Lo compré nuevo
- Lo compré de segunda mano
- Es de alquiler
- Es un regalo
- Otro

* ¿Qué tipo de combustible utiliza el coche que conduce habitualmente?



Marque las entradas que correspondan

- Gasolina
- Gasóleo (diesel)
- Biocombustible
- Híbrido
- Eléctrico
- Gas
- Otro

* ¿Quién es el dueño del coche que conduce habitualmente?



Seleccione una de las siguientes opciones

- Propio
- Familiares próximos
- Empresa
- Estado
- Otro

* ¿Cuántos kilómetros realiza semanalmente con el coche que más usa?
(Seleccione un rango)



Seleccione una de las siguientes opciones

- Menos de 150km
- Entre 150 y 300km
- Entre 300 y 500km
- Entre 500 y 700km
- Más de 700km
- No sabe


Siguiente



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I.-2 ACERCA DEL VEHÍCULO QUE CONDUCE PRINCIPALMENTE

* ¿Cuánto cuesta actualmente el litro del combustible que usa?



Seleccione una de las siguientes opciones

- Menos de 1.15 euros
- Entre 1.15 y 1.25 euros
- Entre 1.25 y 1.35 euros
- Entre 1.35 y 1.45 euros
- Entre 1.45 y 1.55 euros
- Más de 1.55 euros
- No sabe

*
Por favor, indique las siguientes características específicas de su coche actual, si las recuerda

Precio aproximado de compra?



Opción

Sólo se pueden introducir números en este campo.

*
Por favor, ¿indique las siguientes características específicas de su coche actual?
Consumo medio? (litros/100km)



Opción

Sólo se pueden introducir números en este campo.

*
Por favor, ¿indique las siguientes características específicas de su coche actual?
Años?



Opción

Sólo se pueden introducir números en este campo.

* **¿Es su coche actual adaptable a biocombustibles (biodiesel o ethanol) como fuente de energía?**



Seleccione una de las siguientes opciones

- Si
 No
 No sabe

*** ¿Cuál es su grado de satisfacción con su coche actual?**


Seleccione una de las siguientes opciones

- Nada satisfecho
- Poco satisfecho
- Medianamente satisfecho
- Bastante satisfecho
- Muy satisfecho

¿Por favor, díganos por qué ha contestado así?

Opción

[Siguiente](#)

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**Cuestionario
Preferencias
sobre
vehículos**

0%  100%

II. DECISIÓN DE COMPRA DE UN VEHÍCULO

* Aunque no tenga coche ahora, ¿Cómo considera “la decisión de comprar un vehículo”?



Seleccione una de las siguientes opciones

- Sin importancia
- Poca importancia
- Bastante importante
- Muy importante

* ¿A quién consulta fundamentalmente cuando toma una decisión como comprar un vehículo?



Seleccione una de las siguientes opciones

- A nadie
- Familiares
- Amigos
- Concesionarios
- Revistas especializadas
- Publicidad y anuncios (televisión, radio)
- Webs
- Otros. Por favor especificar abajo

Por favor, escriba la justificación de su respuesta aquí:

¿Podría indicarnos, por orden de importancia, las cinco características más importantes que toma en cuenta a la hora de comprar un vehículo?

1

2

3


4

5

[Siguiente](#)

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**Cuestionario
Preferencias
sobre
vehículos**


0% 100%

III. ENERGÍA Y MEDIOAMBIENTE

»

El calentamiento global es un problema que amenaza a los ecosistemas mundiales, comprometiendo el desarrollo sostenible y el bienestar de la Humanidad. La energía que utilizamos en el transporte es la segunda fuente más importante de emisiones de gases de efecto invernadero en España, representando en torno al 25% de las emisiones totales.

Esta información que le damos:



Seleccione una de las siguientes opciones


- le sorprende (¿Por qué?, explique abajo)
- le resulta indiferente
- no le sorprende, ya lo sabía

Por favor, escriba la justificación de su respuesta aquí:

»

El gobierno español plantea en un futuro aumentar los impuestos de matriculación y circulación de los vehículos que tienen altas emisiones de gases de efecto invernadero. Por otra parte, subvenciona con 2000 euros (Programa PIVE-2) la compra de automóviles eficientes menos contaminantes.

Si tuviera que cambiar su automóvil ahora, ¿qué haría?



Seleccione una de las siguientes opciones:

- Elegir uno convencional eficiente, pequeño y menos contaminante para disfrutar de la subvención.
- Comprar un automóvil híbrido y disfrutar de la subvención.
- Comprar el que más me gusta, sin considerar la subvención ni otros posibles impuestos.

*** Con respecto a sus hábitos...**

	Si	No
 Suelo separar y reciclar los residuos sólidos	<input type="radio"/>	<input type="radio"/>
Utilizo equipos de ahorro de energía y/o papel reciclado	<input type="radio"/>	<input type="radio"/>
Asisto a cursos de educación ambiental	<input type="radio"/>	<input type="radio"/>
Soy miembro de una organización ambiental o ecologista	<input type="radio"/>	<input type="radio"/>

Siguiente

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Cuestionario Preferencias sobre vehículos

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IV. VEHÍCULOS HÍBRIDOS

*** ¿Ha oído usted hablar de los vehículos híbridos?**

	<input type="radio"/> Si
	<input type="radio"/> No

* **¿Ha pensado en comprar un vehículo híbrido?**



Seleccione una de las siguientes opciones

- No interesado en absoluto
- No muy interesado
- Ni interesado / Ni desinteresado
- Muy interesado
- Extremadamente interesado

* **¿Conoce usted a alguien que conduzca un vehículo híbrido?**



Marque las entradas que correspondan

- Si, un familiar.
- Si, una amistad.
- Si, un compañero/a de trabajo.
- Si, un vecino/a.
- No, nadie que yo conozca.

* **Con respecto a un vehículo convencional, piensa usted que un vehículo HÍBRIDO**



Marque las entradas que correspondan

- Es más caro
- Tiene el coste de funcionamiento más bajo
- Es menos rápido
- Es menos autónomo
- Es menos potente
- Es menos seguro
- No sabe

* **De los siguientes modelos, ¿cuál cree que contamina menos?**



Seleccione una de las siguientes opciones

- Gasolina
- Gasóleo
- Híbrido
- Biocombustible
- A gas (LPG/GNC)
- No sabe

*** De los siguientes modelos, ¿cuál cree que contamina menos?**

 Seleccione una de las siguientes opciones

- Gasolina
- Gasóleo
- Híbrido
- Biocombustible
- A gas (LPG/GNC)
- No sabe

*** ¿Cuál cree que es el mayor inconveniente del vehículo HÍBRIDO?**

 Opción

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IV.-2 VEHÍCULOS HÍBRIDOS

Un vehículo híbrido es un vehículo de propulsión alternativa combinando un motor eléctrico alimentado por batería y un motor de combustión interna (gasolina o gasóleo).

El coche sabe automáticamente cuando funcionar con el motor convencional y cuando funcionar con electricidad. El coche híbrido es más eficiente que un coche convencional (gasolina o gasóleo) porque un híbrido aprovecha un 40% de la energía que genera, mientras que un vehículo convencional sólo utiliza un 10%.

La eficiencia consiste en que, ahorra en el consumo de combustible, y sobre todo es muy limpio con emisiones de CO2 muy bajas, y muchos de los híbridos están fabricados de una manera que se adaptan a los biocombustibles.

Al contrario de un vehículo eléctrico que tiene problemas de autonomía de la batería, un híbrido nunca tiene que enchufarlo, pues la batería se carga automáticamente con el motor de combustión.

Sin embargo, por el momento, un híbrido tiene un precio superior a un automóvil convencional y no está disponible en muchos modelos.

*** Después de leer la información sobre el vehículo híbrido, ¿se mostraría interesado en comprar un vehículo de estas características en el futuro?**



Seleccione una de las siguientes opciones

- No interesado en absoluto
- No muy interesado
- Ni interesado / Ni desinteresado
- Interesado
- Extremadamente interesado

Por favor, escriba la justificación de su respuesta aquí:

* ¿El precio medio de los vehículos convencionales de tamaño medio (con 5 puertas, una potencia de 100 cv, una velocidad máxima de 160km/h) en España es de aproximadamente 15.000 euros. Está usted dispuesto a pagar un poco más por un híbrido con las mismas características?



- Sí
- No

* ¿Cuánto estaría dispuesto a pagar como máximo por un híbrido sobre el precio medio del automóvil convencional de €15.000,-?



Seleccione una de las siguientes opciones

- 0% (0 euros)
- 10% (1500 euros)
- 20% (3000 euros)
- 30% (4500 euros)
- 40% (6000 euros)
- 50% (7500 euros)
- 60% (9000 euros)
- 70% (10500 euros)
- 80% (12000 euros)
- 90% (13500 euros)
- 100% (15000 euros)
- Más del doble

STELA

*
¿Qué importancia puede tener cada uno de las siguientes medidas para decidirse a cambiar un coche convencional por un coche con menos emisiones?

1 2 3 4 5
Sin importancia Poco importante Neutral Importante Muy importante



	1	2	3	4	5
Exención de impuestos	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Aparcamiento gratuito	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Carriles prioritarios	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Me da buena imagen social	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Coste mantenimiento razonable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Independencia energética	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Subvención gubernamental	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* **¿Con respecto al precio de la gasolina, piensa usted que los biocombustibles son?**



Seleccione una de las siguientes opciones

Más baratos

Más caros

No sabe

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V. ACERCA DE SU PRÓXIMO VEHÍCULO

* ¿Tiene usted previsto comprar o cambiar de coche en el futuro?



Seleccione una de las siguientes opciones

- Probablemente no
- Probablemente si
- Definitivamente si


* ¿Cuándo cree que comprará otro coche?



Seleccione una de las siguientes opciones

- En los próximos 6 meses
- En el próximo año
- Entre 2-5 años
- En más de 5 años

* ¿Qué tamaño preferiría que tuviera su próximo coche?



Seleccione una de las siguientes opciones

- Vehículo pequeño
- Vehículo mediano
- Vehículo grande

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V.-2 ACERCA DE SU PRÓXIMO VEHÍCULO

Teniendo en cuenta las características medias (valores medios; precio = €15.000,-, consumo = €7/100km, emisiones CO2 = 150 g/km) de un coche nuevo de tamaño medio en venta en el mercado español, por favor, indique características específicas que su próximo coche deba tener:

*** Precio aceptable (euros)**



Seleccione una de las siguientes opciones

Por favor escoja...

*** Precio máximo (euro)**

Seleccione una de las siguientes opciones

Por favor escoja...

*** ¿Usado o nuevo?**

Seleccione una de las siguientes opciones

Usado

Nuevo

*** Consumo medio aceptable (euros/100km)**

Seleccione una de las siguientes opciones

Por favor escoja...

*** Consumo medio máximo (euros/100km)**


Seleccione una de las siguientes opciones

Por favor escoja...

*** Adaptable a biocombustible, ¿si o no?**

Sí

No



*
¿Con respecto a la cantidad media de CO₂ que emiten los coches similares a su próximo coche, que margen de emisiones puede tener su próximo coche?

 Seleccione una de las siguientes opciones

- Emisiones de CO₂: No importan
- Emisiones de CO₂: Bajo la media
- Emisiones de CO₂: Igual que la media
- Emisiones de CO₂: Más que la media

* **Ha experimentado cambios en sus hábitos de compra en general debido a la actual crisis económica?**

Seleccione una de las siguientes opciones

- Si, ahora miraré mucho más el precio de los vehículos y artículos en general
- Si, me ha afectado tanto que no compraré ni cambiaré vehículo durante muchos años
- No, seguiré comprando las marcas y modelos que me gusten, independientemente del precio

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VI. EXPERIMENTO DE ELECCIÓN

Imagine que se enfrenta a una decisión de compra de un vehículo. Le presentamos varias opciones A y B de vehículos típicos con características diferentes que se están ofreciendo actualmente en el mercado automovilístico.

Por favor, seleccione la alternativa de automóvil (Automóvil A, Automóvil B, ni A ni B) que Ud compraría. Le presentamos varias elecciones para que Ud seleccione entre los varios automóviles que le mostramos en cada opción.

* Tarjeta 1. Escoja una de las opciones

	Opción A		Opción B	
Tipo de combustible	Convencional		Híbrido	
Precio venta (euros)	12.000		20.000	
Consumo de combustible (euros/100km)	5		7	
Emisiones de CO2 (g/km)	100		150	
Adaptación a biocombustibles	No		Si	
	<input checked="" type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B	

* Tarjeta 2. Escoja una de las opciones

	Opción A		Opción B	
Tipo de combustible	Híbrido		Convencional	
Precio venta (euros)	12.000		20.000	
Consumo de combustible (euros/100km)	7		5	
Emisiones de CO2 (g/km)	150		100	
Adaptación a biocombustibles	Si		No	
	<input checked="" type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B	

* Tarjeta 3. Escoja una de las opciones

	Opción A		Opción B
Tipo de combustible	Híbrido		Convencional
Precio venta (euros)	12.000		20.000
Consumo de combustible (euros/100km)	7		5
Emissiones de CO2 (g/km)	100		150
Adaptación a biocombustibles	No		Si
	<input checked="" type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B

* Tarjeta 4. Escoja una de las opciones

	Opción A		Opción B
Tipo de combustible	Convencional		Híbrido
Precio venta (euros)	20.000		16.000
Consumo de combustible (euros/100km)	7		5
Emissiones de CO2 (g/km)	150		100
Adaptación a biocombustibles	No		Si
	<input checked="" type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B

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VI.-2 EXPERIMENTO DE ELECCIÓN

* Tarjeta 5. Escoja una de las opciones

	Opción A		Opción B	
Tipo de combustible	Convencional		Híbrido	
Precio venta (euros)	16.000		12.000	
Consumo de combustible (euros/100km)	7		5	
Emisiones de CO2 (g/km)	100		150	
Adaptación a biocombustibles	Si		No	
	<input type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B	

* Tarjeta 6. Escoja una de las opciones

	Opción A		Opción B	
Tipo de combustible	Híbrido		Convencional	
Precio venta (euros)	16.000		12.000	
Consumo de combustible (euros/100km)	5		7	
Emisiones de CO2 (g/km)	150		100	
Adaptación a biocombustibles	No		Si	
	<input type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B	

* Tarjeta 7. Escoja una de las opciones

	Opción A		Opción B	
Tipo de combustible	Convencional		Híbrido	
Precio venta (euros)	12.000		20.000	
Consumo de combustible (euros/100km)	5		7	
Emisiones de CO2 (g/km)	150		100	
Adaptación a biocombustibles	Si		No	
	<input type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B	

* Tarjeta 8. Escoja una de las opciones

	Opción A		Opción B	
Tipo de combustible	Híbrido		Convencional	
Precio venta (euros)	20.000		16.000	
Consumo de combustible (euros/100km)	5		7	
Emisiones de CO2 (g/km)	100		150	
Adaptación a biocombustibles	Si		No	
	<input type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B	

Si Ud ha seleccionado la opción "ni automóvil A ni automóvil B" en algunas de las elecciones anteriores, nos podría decir, en sus propias palabras, a qué se debe su elección?

Opción


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Sobre la Encuesta

*** ¿Por favor, puede indicar cómo le resulta la encuesta?**

 Seleccione una de las siguientes opciones

- Fácil
- Un poco difícil
- Algo difícil
- Difícil
- Muy Difícil
- Extremadamente Difícil

*** ¿Ha cambiado su percepción sobre los automóviles híbridos después de rellenar esta encuesta?**


 Seleccione una de las siguientes opciones

- Nada
- Casi nada
- Poco
- Bastante
- Mucho

Por favor, utilice el siguiente espacio para cualquier comentario o sugerencia que usted tenga con respecto a esta encuesta.

Opción

Enviar


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III.6 QUESTIONNAIRE FOR DRIVERS OF LARGE VEHICLE MODELS



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Hola!

La Universidad de Santiago de Compostela está realizando esta encuesta a cerca de su uso de los vehículos y sus preferencias, así como sus opiniones de diversas tecnologías disponibles actualmente en el mercado de la automoción. La encuesta se puede completar en unos 10 minutos.

Su participación es de suma importancia para nosotros. Recuerde que no hay respuestas ni correctas ni incorrectas y que su identidad permanecerá totalmente en el anonimato. Esta encuesta es solo para fines de investigación.

Le damos las gracias por participar!

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CARACTERÍSTICAS SOCIO-DEMOGRÁFICAS

* ¿Sexo?



Femenino

Masculino

* ¿Año de nacimiento?



Opción

Sólo se pueden introducir números en este campo.

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CARACTERÍSTICAS SOCIO-DEMOGRÁFICAS

*** ¿Nivel de formación/estudios?**

Seleccione una de las siguientes opciones

- Sin estudios
- Estudios Primarios / EGB/ Bachiller Elemental o similares
- FPI / FPII o similares
- Bachiller Superior / BUP / COU o similares
- Universitarios de Grado Medio o similares
- Universitarios de Grado Superior o similares

*** ¿Ocupación?**

Seleccione una de las siguientes opciones

- Empleado público
- Autónomo
- Asalariado empresa privada
- Desempleado
- Estudiante
- Labores del hogar
- Jubilado / pensionista
- Otros (Especificar abajo)

Por favor, escriba la justificación de su respuesta aquí:

* ¿Distancia al lugar de su trabajo o estudio? (con respeto al lugar donde vive)



Seleccione una de las siguientes opciones

- Menos de 10km
- Entre 10 y 20 km
- Entre 21 y 30 km
- Entre 31 y 40 km
- Entre 41 y 50 km
- Entre 51 y 60 km
- Entre 61 y 70 km
- Más de 70 km

* ¿Cuántos años lleva usted conduciendo?



Opción

Sólo se pueden introducir números en este campo.

* ¿En promedio, ¿cuántos días a la semana conduce?



Opción

Sólo se pueden introducir números en este campo.

* ¿En un día que conduce, aproximadamente cuántas horas pasa usted conduciendo?



Seleccione una de las siguientes opciones

- Menos de 30 minutos
- 30 minutos - 1 hora
- 1 hora - 2 horas
- 2 horas - 3 horas
- 3 horas - 4 horas
- 4 horas - 5 horas
- Más de 5 horas
- No conduzco nunca

* ¿Ingreso mensual familiar del hogar?



Seleccione una de las siguientes opciones

- Menos de 300 €
- 300 - 600 €
- 600 - 1200 €
- 1.200 - 1800 €
- 1800 - 2400 €
- 2400 - 3000 €
- 3000 - 4000 €
- Más de 4000 €

* ¿Numero de personas totales que viven en su hogar?



Seleccione una de las siguientes opciones

- 1
- 2
- 3
- 4
- 5 o mas

* ¿Cuántas menores de 10 años?



Opción

Sólo se pueden introducir números en este campo.


* ¿Cuántas tienen entre 10 y 18 años?



Opción

Sólo se pueden introducir números en este campo.

*** ¿Nacionalidad?**

 Seleccione una de las siguientes opciones:

- Española
- Extranjera (escribe su país abajo)

Por favor, escriba la justificación de su respuesta aquí:

*** Provincia**



Opción

*** Ciudad/Localidad**



Opción

*** ¿Código Postal?**



Opción

Sólo se pueden introducir números en este campo.

Siguiente



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Introducción

* ¿Cuántos coches hay en su casa actualmente?

 Seleccione una de las siguientes opciones

- 0
- 1
- 2
- 3 o mas

* ¿Es usted el conductor principal de uno de estos coches?

 Sí

No

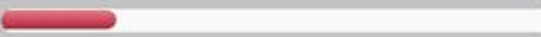
En la siguiente sección, le vamos a preguntar sobre las características del coche que conduce habitualmente. En caso de que ud haya respondido "No" en P2, puede completar esta sección refiriéndose al coche más usado de su hogar.

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I. ACERCA DEL VEHÍCULO QUE CONDUCE PRINCIPALMENTE

* ¿Que vehículo conduce principalmente?



Seleccione una de las siguientes opciones

- Audi
- BMW
- Chevrolet
- Citroën
- Fiat
- Ford
- Honda
- Hyundai
- Iveco
- Mazda
- Mercedes
- Mitsubishi
- Nissan
- Opel
- Peugeot
- Porsche
- Renault
- Seat
- Toyota
- Volkswagen
- Otra (especificar abajo)

Por favor, escriba la justificación de su respuesta aquí:

* ¿Carrocería?



Seleccione una de las siguientes opciones

- Utilitario (Opel Corsa, Seat Ibiza, Renault Clio, ...)
- Compacto (Peugeot 308, Honda Civic, Ford Focus, ...)
- Berlina (Volkswagen Passat, Seat Exeo, Audi A4, ...)
- Ranchera (Audi A4 Avant, BMW Serie 3 Touring, ...)
- Monovolumen (Volkswagen Touran, Renault Espace, ...)
- Todoterreno (Audi Q7, Porsche Cayenne, ...)
- Deportivo (BMW Z4, Audi TT, Porsche Cayman, ...)
- Descapotable (Audi A5 Cabrio, BMW Serie 6 Cabrio, ...)

* ¿En qué condiciones obtuvo el coche que conduce habitualmente?



Seleccione una de las siguientes opciones

- Lo compré nuevo
- Lo compré de segunda mano
- Es de alquiler
- Es un regalo
- Otro

* ¿Qué tipo de combustible utiliza el coche que conduce habitualmente?



Marque las entradas que correspondan

- Gasolina
- Gasóleo (diesel)
- Biocombustible
- Híbrido
- Eléctrico
- Gas
- Otro

* ¿Quién es el dueño del coche que conduce habitualmente?



Seleccione una de las siguientes opciones

- Propio
- Familiares próximos
- Empresa
- Estado
- Otro

* ¿Cuántos kilómetros realiza semanalmente con el coche que más usa?
(Seleccione un rango)



Seleccione una de las siguientes opciones

- Menos de 150km
- Entre 150 y 300km
- Entre 300 y 500km
- Entre 500 y 700km
- Más de 700km
- No sabe

Siguiente



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I.-2 ACERCA DEL VEHÍCULO QUE CONDUCE PRINCIPALMENTE

* ¿Cuánto cuesta actualmente el litro del combustible que usa?



Seleccione una de las siguientes opciones

- Menos de 1.15 euros
- Entre 1.15 y 1.25 euros
- Entre 1.25 y 1.35 euros
- Entre 1.35 y 1.45 euros
- Entre 1.45 y 1.55 euros
- Más de 1.55 euros
- No sabe

*
Por favor, indique las siguientes características específicas de su coche actual, si las recuerda

Precio aproximado de compra?



Opción

Sólo se pueden introducir números en este campo.

*
Por favor, ¿indique las siguientes características específicas de su coche actual?
Consumo medio? (litros/100km)



Opción

Sólo se pueden introducir números en este campo.

*
Por favor, ¿indique las siguientes características específicas de su coche actual?
Años?



Opción

Sólo se pueden introducir números en este campo.

* **¿Es su coche actual adaptable a biocombustibles (biodiesel o ethanol) como fuente de energía?**



Seleccione una de las siguientes opciones

- Si
 No
 No sabe

¿Cuál es su grado de satisfacción con su coche actual?

Seleccione una de las siguientes opciones

- Nada satisfecho
- Poco satisfecho
- Medianamente satisfecho
- Bastante satisfecho
- Muy satisfecho

¿Por favor, díganos por qué ha contestado así?

Opción

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II. DECISIÓN DE COMPRA DE UN VEHÍCULO

*** Aunque no tenga coche ahora, ¿Cómo considera “la decisión de comprar un vehículo”?**



Seleccione una de las siguientes opciones

- Sin importancia
- Poca importancia
- Bastante importante
- Muy importante

*** ¿A quién consulta fundamentalmente cuando toma una decisión como comprar un vehículo?**



Seleccione una de las siguientes opciones

- A nadie
- Familiares
- Amigos
- Concesionarios
- Revistas especializadas
- Publicidad y anuncios (televisión, radio)
- Webs
- Otros. Por favor especificar abajo

Por favor, escriba la justificación de su respuesta aquí:

¿Podría indicarnos, por orden de importancia, las cinco características más importantes que toma en cuenta a la hora de comprar un vehículo?

1

2

3

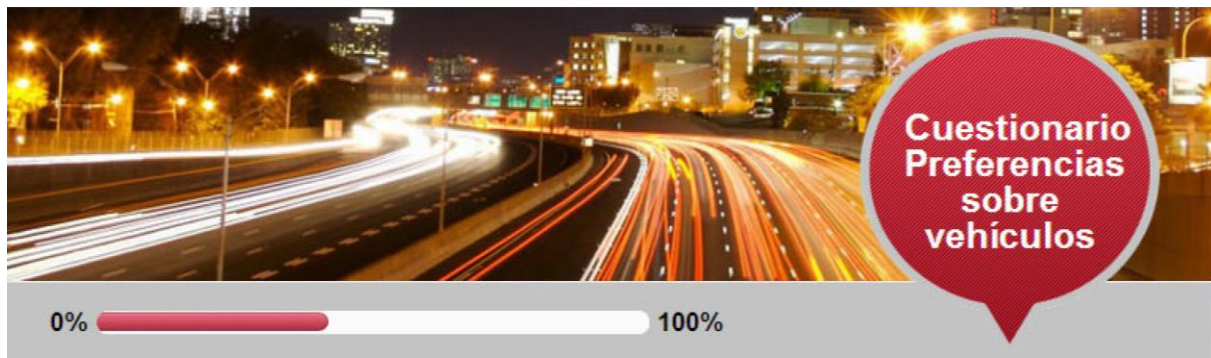
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III. ENERGÍA Y MEDIOAMBIENTE

*

El calentamiento global es un problema que amenaza a los ecosistemas mundiales, comprometiendo el desarrollo sostenible y el bienestar de la Humanidad. La energía que utilizamos en el transporte es la segunda fuente más importante de emisiones de gases de efecto invernadero en España, representando en torno al 25% de las emisiones totales.

Esta información que le damos:



Seleccione una de las siguientes opciones

- le sorprende (¿Por qué?, explique abajo)
- le resulta indiferente
- no le sorprende, ya lo sabía

Por favor, escriba la justificación de su respuesta aquí:

*

El gobierno español plantea en un futuro aumentar los impuestos de matriculación y circulación de los vehículos que tienen altas emisiones de gases de efecto invernadero. Por otra parte, subvenciona con 2000 euros (Programa PIVE-2) la compra de automóviles eficientes menos contaminantes.


Si tuviera que cambiar su automóvil ahora, ¿qué haría?



Seleccione una de las siguientes opciones

- Elegir uno convencional eficiente, pequeño y menos contaminante para disfrutar de la subvención.
- Comprar un automóvil híbrido y disfrutar de la subvención.
- Comprar el que más me gusta, sin considerar la subvención ni otros posibles impuestos.



0%  100%

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- Comprar el que más me gusta, sin considerar la subvención ni otros posibles impuestos.

*** Con respecto a sus hábitos...**



	Si	No
Suelo separar y reciclar los residuos sólidos	<input type="radio"/>	<input type="radio"/>
Utilizo equipos de ahorro de energía y/o papel reciclado	<input type="radio"/>	<input type="radio"/>
Asisto a cursos de educación ambiental	<input type="radio"/>	<input type="radio"/>
Soy miembro de una organización ambiental o ecologista	<input type="radio"/>	<input type="radio"/>

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IV. VEHÍCULOS HÍBRIDOS

*** ¿Ha oído usted hablar de los vehículos híbridos?**



Sí

No

*** ¿Ha pensado en comprar un vehículo híbrido?**



Seleccione una de las siguientes opciones

- No interesado en absoluto
- No muy interesado
- Ni interesado / Ni desinteresado
- Muy interesado
- Extremadamente interesado

*** ¿Conoce usted a alguien que conduzca un vehículo híbrido?**



Marque las entradas que correspondan

- Si, un familiar.
- Si, una amistad.
- Si, un compañero/a de trabajo.
- Si, un vecino/a.
- No, nadie que yo conozca.

*** Con respecto a un vehículo convencional, piensa usted que un vehículo HÍBRIDO**



Marque las entradas que correspondan

- Es más caro
- Tiene el coste de funcionamiento más bajo
- Es menos rápido
- Es menos autónomo
- Es menos potente
- Es menos seguro
- No sabe


*** De los siguientes modelos, ¿cuál cree que contamina menos?**



Seleccione una de las siguientes opciones


- Gasolina
- Gasóleo
- Híbrido
- Biocombustible
- A gas (LPG/GNC)
- No sabe

*** De los siguientes modelos, ¿cuál cree que contamina menos?**


 Seleccione una de las siguientes opciones

- Gasolina
- Gasóleo
- Híbrido
- Biocombustible
- A gas (LPG/GNC)
- No sabe

*** ¿Cuál cree que es el mayor inconveniente del vehículo HÍBRIDO?**

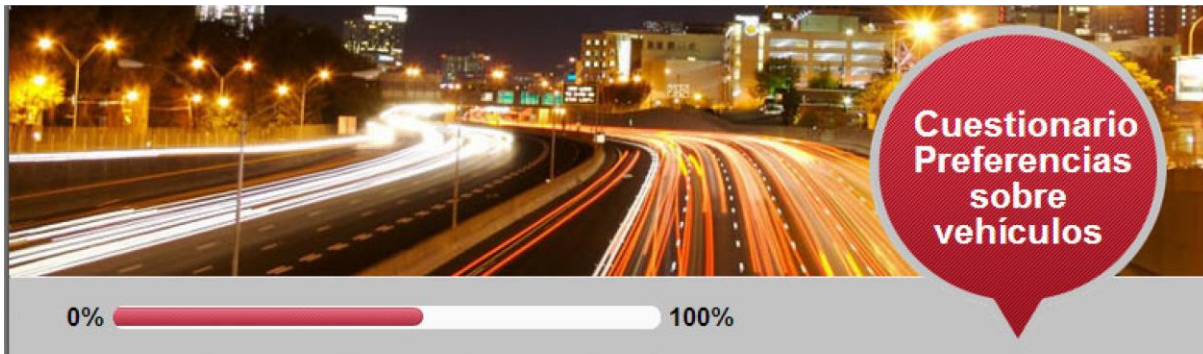
 Opción

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IV.-2 VEHÍCULOS HÍBRIDOS

Un vehículo híbrido es un vehículo de propulsión alternativa combinando un motor eléctrico alimentado por batería y un motor de combustión interna (gasolina o gasóleo).

El coche sabe automáticamente cuando funcionar con el motor convencional y cuando funcionar con electricidad. El coche híbrido es más eficiente que un coche convencional (gasolina o gasóleo) porque un híbrido aprovecha un 40% de la energía que genera, mientras que un vehículo convencional sólo utiliza un 10%.

La eficiencia consiste en que, ahorra en el consumo de combustible, y sobre todo es muy limpio con emisiones de CO2 muy bajas, y muchos de los híbridos están fabricados de una manera que se adaptan a los biocombustibles.

Al contrario de un vehículo eléctrico que tiene problemas de autonomía de la batería, un híbrido nunca tiene que enchufarlo, pues la batería se carga automáticamente con el motor de combustión.

Sin embargo, por el momento, un híbrido tiene un precio superior a un automóvil convencional y no está disponible en muchos modelos.

*** Después de leer la información sobre el vehículo híbrido, ¿se mostraría interesado en comprar un vehículo de estas características en el futuro?**



Seleccione una de las siguientes opciones

- No interesado en absoluto
- No muy interesado
- Ni interesado / Ni desinteresado
- Interesado
- Extremadamente interesado

Por favor, escriba la justificación de su respuesta aquí:

* ¿El precio medio de los vehículos convencionales de tamaño medio (con 5 puertas, una potencia de 100 cv, una velocidad máxima de 160km/h) en España es de aproximadamente 15.000 euros. Está usted dispuesto a pagar un poco más por un híbrido con las mismas características?



Sí

No

* ¿Cuánto estaría dispuesto a pagar como máximo por un híbrido sobre el precio medio del automóvil convencional de €15.000,-?



Seleccione una de las siguientes opciones

0% (0 euros)

10% (1500 euros)

20% (3000 euros)

30% (4500 euros)

40% (6000 euros)

50% (7500 euros)

60% (9000 euros)

70% (10500 euros)

80% (12000 euros)

90% (13500 euros)

100% (15000 euros)

Más del doble

STELA

*
¿Qué importancia puede tener cada uno de las siguientes medidas para decidirse a cambiar un coche convencional por un coche con menos emisiones?

1 2 3 4 5
Sin importancia Poco importante Neutral Importante Muy importante

	1	2	3	4	5
 Exención de impuestos	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Aparcamiento gratuito	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Carriles prioritarios	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Me da buena imagen social	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Coste mantenimiento razonable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Independencia energética	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Subvención gubernamental	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* **¿Con respecto al precio de la gasolina, piensa usted que los biocombustibles son?**

Seleccione una de las siguientes opciones

- Más baratos
- Más caros
- No sabe



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V. ACERCA DE SU PRÓXIMO VEHÍCULO

*** ¿Tiene usted previsto comprar o cambiar de coche en el futuro?**



Seleccione una de las siguientes opciones

- Probablemente no
- Probablemente si
- Definitivamente si

*** ¿Cuándo cree que comprará otro coche?**



Seleccione una de las siguientes opciones

- En los próximos 6 meses
- En el próximo año
- Entre 2-5 años
- En más de 5 años

*** ¿Qué tamaño preferiría que tuviera su próximo coche?**



Seleccione una de las siguientes opciones

- Vehículo pequeño
- Vehículo mediano
- Vehículo grande

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V.-2 ACERCA DE SU PRÓXIMO VEHÍCULO

Teniendo en cuenta las características medias (valores medios; precio = €15.000,-, consumo = €7/100km, emisiones CO2 = 150 g/km) de un coche nuevo de tamaño medio en venta en el mercado español, por favor, indique características específicas que su próximo coche deba tener:

*** Precio aceptable (euros)**

 Seleccione una de las siguientes opciones


Por favor escoja...

*** Precio máximo (euro)**


Seleccione una de las siguientes opciones

Por favor escoja...

<p>* ¿Usado o nuevo?</p> <p>Seleccione una de las siguientes opciones</p> <p><input type="radio"/> Usado</p> <p><input type="radio"/> Nuevo</p>
<p>* Consumo medio aceptable (euros/100km)</p> <p>Seleccione una de las siguientes opciones</p> <p>Por favor escoja... <input type="button" value="v"/></p>
<p>* Consumo medio máximo (euros/100km)</p> <p>Seleccione una de las siguientes opciones</p> <p>Por favor escoja... <input type="button" value="v"/></p>
<p>* Adaptable a biocombustible, ¿si o no?</p> <p><input type="radio"/> Sí</p> <p><input type="radio"/> No</p>



*
¿Con respecto a la cantidad media de CO2 que emiten los coches similares a su próximo coche, que margen de emisiones puede tener su próximo coche?

 Seleccione una de las siguientes opciones


- Emisiones de CO2: No importan
- Emisiones de CO2: Bajo la media
- Emisiones de CO2: Igual que la media
- Emisiones de CO2: Más que la media

* **Ha experimentado cambios en sus hábitos de compra en general debido a la actual crisis económica?**


Seleccione una de las siguientes opciones

- Sí, ahora miraré mucho más el precio de los vehículos y artículos en general
- Sí, me ha afectado tanto que no compraré ni cambiaré vehículo durante muchos años
- No, seguiré comprando las marcas y modelos que me gusten, independientemente del precio

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VI. EXPERIMENTO DE ELECCIÓN

Imagine que se enfrenta a una decisión de compra de un vehículo. Le presentamos varias opciones A y B de vehículos típicos con características diferentes que se están ofreciendo actualmente en el mercado automovilístico.

Por favor, seleccione la alternativa de automóvil (Automóvil A, Automóvil B, ni A ni B) que Ud compraría. Le presentamos varias elecciones para que Ud seleccione entre los varios automóviles que le mostramos en cada opción.

*** Tarjeta 1. Escoja una de las opciones**

	Opción A	Opción B
Tipo de combustible	Convencional	Híbrido
Precio venta (euros)	22.000	30.000
Consumo de combustible (euros/100km)	8	10
Emisiones de CO2 (g/km)	130	180
Adaptación a biocombustibles	No	Si
	<input type="radio"/> Opción A	<input type="radio"/> Opción B
	<input type="radio"/> Ni A ni B	

*** Tarjeta 2. Escoja una de las opciones**

	Opción A	Opción B
Tipo de combustible	Híbrido	Convencional
Precio venta (euros)	22.000	30.000
Consumo de combustible (euros/100km)	10	8
Emisiones de CO2 (g/km)	180	130
Adaptación a biocombustibles	Si	No
	<input type="radio"/> Opción A	<input type="radio"/> Opción B
	<input type="radio"/> Ni A ni B	

*** Tarjeta 3. Escoja una de las opciones**

Tipo de combustible	Opción A Híbrido	Opción B Convencional
Precio venta (euros)	22.000	30.000
Consumo de combustible (euros/100km)	10	8
Emisiones de CO2 (g/km)	130	180
Adaptación a biocombustibles	No	Si

Opción A Opción B

Ni A ni B

*** Tarjeta 4. Escoja una de las opciones**

Tipo de combustible	Opción A Convencional	Opción B Híbrido
Precio venta (euros)	30.000	26.000
Consumo de combustible (euros/100km)	10	8
Emisiones de CO2 (g/km)	180	130
Adaptación a biocombustibles	No	Si

Opción A Opción B

Ni A ni B

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0% 100%

VI.-2 EXPERIMENTO DE ELECCIÓN

*** Tarjeta 5. Escoja una de las opciones**

	Opción A		Opción B
Tipo de combustible	Convencional		Híbrido
Precio venta (euros)	26.000		22.000
Consumo de combustible (euros/100km)	10		8
Emisiones de CO2 (g/km)	130		180
Adaptación a biocombustibles	Si		No
	<input type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input checked="" type="radio"/> Opción B

*** Tarjeta 6. Escoja una de las opciones**

	Opción A		Opción B
Tipo de combustible	Híbrido		Convencional
Precio venta (euros)	26.000		22.000
Consumo de combustible (euros/100km)	8		10
Emisiones de CO2 (g/km)	180		130
Adaptación a biocombustibles	No		Si
	<input type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B

*** Tarjeta 7. Escoja una de las opciones**

	Opción A		Opción B	
Tipo de combustible	Convencional		Híbrido	
Precio venta (euros)	22.000		30.000	
Consumo de combustible (euros/100km)	8		10	
Emisiones de CO2 (g/km)	180		130	
Adaptación a biocombustibles	Si		No	
	<input type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B	

*** Tarjeta 8. Escoja una de las opciones**

	Opción A		Opción B	
Tipo de combustible	Híbrido		Convencional	
Precio venta (euros)	30.000		26.000	
Consumo de combustible (euros/100km)	8		10	
Emisiones de CO2 (g/km)	130		180	
Adaptación a biocombustibles	Si		No	
	<input type="radio"/> Opción A	<input type="radio"/> Ni A ni B	<input type="radio"/> Opción B	

Si Ud ha seleccionado la opción "ni automóvil A ni automóvil B" en algunas de las elecciones anteriores, nos podría decir, en sus propias palabras, a qué se debe su elección?

Opción

Siguiente



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Sobre la Encuesta

*** ¿Por favor, puede indicar cómo le resulta la encuesta?**



Seleccione una de las siguientes opciones

- Fácil
- Un poco difícil
- Algo difícil
- Difícil
- Muy Difícil
- Extremadamente Difícil

*** ¿Ha cambiado su percepción sobre los automóviles híbridos después de rellenar esta encuesta?**



Seleccione una de las siguientes opciones

- Nada
- Casi nada
- Poco
- Bastante
- Mucho

Por favor, utilice el siguiente espacio para cualquier comentario o sugerencia que usted tenga con respecto a esta encuesta.

Opción

Enviar



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