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DISSERTAÇÃO

CAN GREEN TAXATION TRIGGER PLUG-IN HYBRID ACQUISITION?

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Abstract

This paper aims to determine if the green tax system, introduced in Portugal in 2014, is able to influence the interest for plug-in hybrid vehicles.

The Literature Review identifies a number of factors that influence the interest for plug-in hybrid vehicles, including access to financial incentives. On this basis, a questionnaire survey was carried out jointly between individual and business users of light vehicles to assess the effect of those factors on the interest to purchase a plug-in hybrid. Being so, survey questions were made to assess consumers environmental awareness, technology taste, independence from oil producers, image and access to financial incentives like hood. The interest for plug-in hybrids is also measured by the first two question of the questionnaire survey.

While we have not been able to develop the business sample analysis, at the individual sample, the structural equation analysis found a significant positive effect of the Portuguese green tax system over the interest for acquiring a plug-in hybrid. However, it does not grant an amount capable of triggering a large-scale effect once, in mean terms, drivers ask for a much lower gap between plug-in hybrids and ordinary vehicles prices. A significant positive effect of driver´s vehicle size on interest for plug-in hybrids was also found.

Keywords: green taxation systems; plug-in hybrid vehicles

Resumo

Este estudo tem como objetivo determinar se a fiscal verde, introduzida em Portugal em 2014, é capaz de influenciar o interesse por veículos híbridos plug-in.

A revisão de literatura identifica uma série de fatores que influenciam o interesse por veículos híbridos plug-in, de entre os quais se destaca o acesso a incentivos financeiros. Nesta base, um inquérito por questionário foi realizado entre usuários individuais e empresariais de veículos ligeiros de passageiros para avaliar o efeito desses fatores no interesse em adquirir um híbrido plug-in. Assim sendo, foram colocadas questões para avaliar a consciência ambiental dos consumidores, o gosto por tecnologia, a independência dos produtores de petróleo, a imagem e a apreciação do acesso a incentivos financeiros. O interesse pelos híbridos plug-in também é medido pelas duas primeiras questões do inquérito por questionário.

Embora não tenhamos sido capazes de desenvolver a análise da amostra de utilizadores empresariais, na amostra de utilizadores individuais, a análise de equações estruturais encontrou um efeito positivo e significativo da fiscalidade verde sobre o interesse pela aquisição de um híbrido plug-in. No entanto, os incentivos da fiscalidade verde não concedem um montante capaz de desencadear um efeito de grande escala. Também foi encontrado um efeito positivo e significativo entre a dimensão do veículo conduzido atualmente sobre o interesse por veículos híbridos plug-in.

Palavras chave: fiscalidade verde; veículos híbridos plug-in

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Abbreviations and Acronyms List

CSR – Corporate social responsibility

OECD – Organization for Economic Co-operation and Development

VAT – Value added tax

STV – Subject-to-variables

KMO – Kaiser-Meyer-Olkin

VS – Vehicle size

R – Place of residence

INS – Income Scale

HS – Household size

EDUC – Education level

INT – Interest to acquire a plug-in hybrid

OP – Independence from oil producers

I – Image

T – Technology

E – Environmental awareness

CMIN – Minimum discrepancy

DF – Degrees of freedom

RMSEA – Root Mean Square Error of Approximation

GFI – goodness of fit index

AGFI – Adjusted goodness of fit index

RMR – Root Mean Square Residual

Contents

1 Introduction

In 2014, the Portuguese Government decided to "start reviewing environmental and energy taxation, as well as promoting a new tax framework, through the development of mechanisms that allow the internalization of environmental externalities" [1]. Thus, a commission was created that year with the mission of "redefining the fundamental legal bases of the environmental and energy taxation system" (Commission for the Reform of Green Taxation, 2014). One such redefinition is about plug-in hybrid vehicles, an important instrument for reducing emissions in the transport sector. The following study aims, therefore, to understand if this green tax reform can trigger plug-in hybrid vehicle acquisition.

Plug-in hybrid vehicles offer benefits both to the environment and the consumer. In addition to using combustion engines, the use of an electric motor by plug-in hybrid vehicle can significantly reduce greenhouse gas emissions in transport (Duvall, Knipping, Alexande, Tonachel, & Clark, 2007); (Smith, 2010). Plug-in hybrid vehicles may also play an important role in the efficiency of energy distribution. As the fossil fuels and their derivatives are a finite and increasingly scarce commodity, the potential for the use of plug-in hybrid vehicle can mitigate the effects of peaks in the demand for these fuels (Andersson, et al., 2010).

Consequently, a green energy tax reform was shaped throw out Europe, creating financial systems to favor the acquisition and use of plug-in hybrids. The main purpose of this action is to shape individuals' behaviors towards more sustainable transport practices. However, the motivations for acquiring a plug-in hybrid vehicle may go beyond the incentives provided, and cannot be explained solely by economic factors

[1] Ministerial Order n. º 1962/2014, February 7th 2014

(Klein, 2007). Environmental awareness, the technological aspect, reduction of oil dependence and image are extremely important factors in the interest of a plug-in hybrid vehicle (Ritsuko & Sevastyanova, 2011). In this context, we want to test if the Portuguese green taxation system may be able to shape the interest of people in general for the acquisition of a plug-in hybrid vehicle, among other factors identified in previous studies. These green tax systems can fail either because of insufficient amounts provided or because of their limitations in shaping behavior at this level. A structural equations model will be assembled containing the explanatory factors of interest, and a confirmatory factor analysis will be performed.

This analysis reveals that there is a significant and positive relationship between access to financial incentives and the size of the vehicle driven with the interest for plug-in hybrid vehicles. The effect of the incentives over interest for these vehicles is consistent with literature, but the same does not happen with the size of the vehicle. The positive effect of owning a large vehicle verified here is contrary to what has been suggested by previous studies. The larger households in the sample call for an even greater incentive to consider the acquisition of a plug-in hybrid, which is consistent with the literature. Although, it was not possible to confirm that the other factors identified in previous studies as predictors for the purchase of a plug-in hybrid are also able to justify the interest of individuals in general.

This study adds a different contribution, as it seeks to effectively understand whether green reform is likely to influence drivers' choices in general. So far, exploratory studies have been presented mainly using samples of drivers who already had a hybrid, and where the main purpose was not always to explore the effects of tax policy. In turn, here we will try to confirm the effect of green policy in the generality of drivers. The study begins by developing a literary review, which in first instance shows previous

works that explored the structure of factors that envisaged interest in plug-in hybrid vehicles and, in a second instance, reveals the Portuguese and European fiscal framework for green taxation.

The third chapter develops descriptive statistics of the used sample, also presenting sample suitability tests to perform the factorial analysis and describes the individual and business models. Then, in the fourth chapter, the results of the model are returned, being the business sample insufficient to carry out the analysis. Also in this chapter, the model fit is studied and two modified models are presented. The simplified model, presented at the end, is built on the factors of access to financial incentives and vehicle size, which presented statistically significant and positive effect on interest for plug-in hybrids.

The last chapter corresponds to the conclusions. The study yields tax policy contributions by confirming the government`s ability to influence drivers' choices, although the Portuguese green taxation system does not grant access to an amount capable of having a large-scale effect. This chapter also shows the limitations of the study and the suggestions for future research.

2 Literature Review

2.1 Motivations to acquire a Hybrid Vehicle

The introduction of a green tax system aims to shape the behaviors of individuals and guide them towards more sustainable practices. To encourage the purchase of hybrid vehicles, green taxation systems incorporates financial incentives regarding corporate income and motor vehicle taxations. However, the literature reveals that there are motivations for buying a hybrid that go beyond the scope of these discounts.

Ritsuko and Sevastyanova (2011) study subdivides the motivations for the adoption of a plug-in hybrid in five main groups. The first group refers precisely to benefits and other tax advantages. Consumers consider the financial benefits, especially for their interest in improving fuel efficiency and saving money on gasoline or diesel (Heffner, Kurani, & Turrentine, Symbolism in California's early market for hybrid, 2007); (Klein, 2007). Consumers tend to switch more expensive, larger-displacement vehicles for less powerful and more fuel-efficient hybrids in order to reduce costs (Haan, Mueller, & Peters, 2006). As a rule, the option for a plug-in hybrid comes as a response to rising fuel prices (mainly oil products) and tax incentives, which is seen as a way to reduce energy consumption and increase energy security (Gallagher & Muehlegger, 2008). But while access to incentives is an appealing aspect for vehicle buyers, they may not always be worth enough to offset the high prices of these technologies (Krause, Lane, Carley, & Graham, 2016), what can undermine the prior goal for green tax reform, which is to influence a large scale sustainable behavior.

The second group is related to a characteristic symbolism of hybrids, environmentalism. Some consumers take into account the preservation of the environment, demonstrate high levels of environmental awareness and take actions to reduce their ecological footprint (Heffner, Kurani, & Turrentine, Symbolism in California's early market for hybrid, 2007). They express and communicate their concerns about the environment, seeking a hybrid as a way to show and highlight this concern (Klein, 2007). The works of (Gallagher & Muehlegger, 2008) and (Turrentine & Kurani, 2007) also point out that these buyers explicitly seek to be seen driving an environmentally friendly car, which may lead them to opt for better-known hybrid models (preferring to drive a Toyota Prius to a Honda Insight, for example). Some hybrid buyers

actually do not even consider the consumption of their vehicle, their decision is based solely on their environmental awareness (Turrentine & Kurani, 2007).

The third group is concerned by compliance with the norms of the community in which car buyers are inserted (Ritsuko & Sevastyanova, 2011). Environment friendly consumers tend to cluster geographically into green communities. This reality creates a stigma that the possession of a hybrid vehicle is the reflection of sharing the community values and norms (Kahn, 2007). The detach of this conception factor from environmental awareness is also done by Krupa, et al., (2014) and other recent authors, obtaining more explanatory power in their analyses.

The fourth group emerges from studies that show that, for some consumers, new technologies are intrinsically attractive (Turrentine & Kurani, 2007). These consumers have a positive attitude towards innovation and are prone to adopt new technologies (Heffner, 2007). More recently, Krupa, et al., (2014) made a similar work to Ritsuko and Sevastyanova (2011). Regarding the technological factor, these authors identify the two concerns most frequently indicated by survey participants based on their study: the costs of battery replacement and other battery-related concerns, as well as the difficulty of repairing the electric motors. These results are also supported by previous studies by Caperello and Kurani (2012) and Graham-Rowe, et al., (2012). Other studies suggest that the reliability of plug-in hybrid vehicle is a key consideration for consumers most willing to adopt them (Deloitte Consulting LLP, 2010), which combines the duration of the vehicle's battery in progress, charging time, durability of the electrical components, and access to qualified maintenance (Caperello & Kurani, 2012); (Graham-Rowe, et al., 2012). The willingness to take a chance with new technologies, more difficult of handle, repair and maintain could be an important issue when opting for a plug-in hybrid.

In is turn, the fifth group is related to the concern of the consumers to reach the independence of the oil producers through the reduction of the consumption (Heffner, Kurani, & Turrentine, Symbolism in California's early market for hybrid, 2007). Buyers attitude towards plug-in hybrids could be very influenced by their power saving intentions, once sustainable energy consumption behavior has a strong relationship with energy conservation intentions (Low Sheau-Ting, 2016). Therefore, a plug-in hybrid can be able to meet these buyer's expectations.

Krupa, et al., (2014) add a factor that relates to the current vehicle that the respondent possesses. In agreement with the Deloitte Consulting LLP (2010) and Hidrue, Parsons, Kempton and Gardner (2011), the authors discover a positive association ($p < 0.0001$) between the current vehicle class and the expressed will of a participant in considering a compact plug-in hybrid vehicle. The author's research has shown that those who currently own larger vehicles are less likely to adopt a plug-in hybrid vehicle, which are mostly compact models. Also, demographic factors, like education or household size and income can influence hybrid purchase. Education level can have a positive effect on the adoption of green cars (Mannberg, Jansson, Pettersson, Brännlund, & Lindgren, 2014), while low income groups may not be so interested in hybrid vehicles. The wish to buy a family size vehicle also deteriorates the interest for hybrids, being these smaller vehicles that may not be considered family fitted. Therefore, household size has to be considered.

As we can then verify, there are several motivations for buying a hybrid beyond financial incentives, with special emphasis on the environmental factor, in some cases sufficient condition for the purchasing act. This implies that, above of all, the adoption of a plug-in hybrid is justified not only on a cost-benefit relationship, it cannot be explained by economic factors alone (Klein, 2007). It makes the sense that we can only examine

interest, not only considering the Portuguese green tax system influence, but also other factors identified in previous studies. So, this chapter provides the basis for the structural equations model to be developed over the five factors and social economic aspects referred, like education, household size or vehicle size. But to do it so, and since the study will try to reach business drivers, some aspects of business practice, Portuguese taxation and plug-in market, need a closer look. The following chapters exhibit and explore these subjects.

2.2 Corporate Social Responsibility

In a business context, the decision to buy a vehicle is sometimes in the hands of the employee who will use it. However, there are cases where the employee does not have freedom of choice or is directed to make a specific purchase by the company where he works. Basically, in some cases the corporate policy overlaps, the decisions of buying and selling vehicles are in the hands of management and not on employees. So, this is not an individual decision. It is then interesting to understand the business motivations that can lead to the adoption of a plug-in hybrid vehicle.

Currently, the concept of corporate social responsibility puts the principle of rationality in suspicion while conducting business. Responsible practices in business add value to companies and allows the unblocking of benefits that do not come from applying the principle of rationality (Carroll, 1999). Thus, Zadek argued that companies seek to implement CSR strategies to defend their reputations, demonstrate their benefits over their costs, integrate with their broader strategies, learn, innovate and manage risk (Zadek, 2000). In a more recent work (Kurucz, Colbert, & Wheeler, 2008) also define four commercial motivation vectors of corporate social responsibility that overlap with Zadek´s. They maintain that there are four different motivational groups that include cost

and risk reduction, gaining competitive advantage, developing a reputation/legitimacy and pursuing win-win situations through the value of synergistic creation.

In this subchapter, we find that companies have the motivation to carry out corporate social responsibility strategies in order to obtain positive results through their practices. Consequently, some companies, seeking access to financial incentives, may choose to purchase a plug-in hybrid as a matter of corporate social responsibility strategy. Also, being environmentally friendly cars, a company can look for these vehicles in order to emphasize its environmental concern and convey a responsible image, for example.

2.3 Motivations for the introduction of the Green Tax Law in Portugal

The Law no. 82-D / 2014 of 31 December, known as the "green taxation system law", amends environmental tax rules in the energy, emissions, transport, water, waste, land use, forest and biodiversity sectors, A system for taxing plastic bags and a scheme to encourage car scrappage in the context of reforming environmental taxation[2].

The draft of the green tax reform was debated at the Portuguese Parliament on November 26th, 2014. In the (I Series - Issue 24, 2014) of the AR Diary, it is possible to rediscover the debate that took place on that date. We easily realize that the green tax reform has been greatly contested by the opposition, since it leads households to pay more personal income tax. However, almost nothing was contested or debated about the car incentives, with only a reference being made to them. Nevertheless, the Minister for the Environment, Territory Planning and Energy states the following:

> "Madam President and Honorable Members, let us make no mistake: this is not a debate on public finances and taxation, this is not a debate on energy and environmental policy; This is essentially a debate on a new model of development, growth and employment. [...]. It was in the context of green growth that we decided to move forward with the green tax reform process 10 months ago, firstly because there is a need to improve efficiency in resource consumption, reduce

[2] Law no. 82-D / 2014 of 31 December.

energy dependence from abroad and to induce more sustainable activities and consumption behavior, enhancing the freedom and responsibility of citizens and businesses."

This contextualization of the Minister helps to understand that a green taxation system has not been introduced for tax revenue purposes. It is in fact an instrument that seeks to shape behavior and to induce economic and consumer agents into more sustainable and environmentally friendly practices. The green taxation system introduces incentives in the corporate income tax code and the motor tax code, which will be detailed in the upcoming sections.

2.4 Green Taxation Framework: Tax Incentives for the purchase of green vehicles in Portugal and EU countries

The commission prepared the draft for green tax reform with the objective encourage, among others, the purchase of plug-in hybrid vehicles. With the support of the Portuguese embassies, it has carried out a work of collecting information "updated on experiences and policy orientations regarding green taxation, respectively in the European Commission and in the OECD" (Comissão para a Reforma da Fiscalidade Verde, 2014). This survey and subsequent processing of data by the commission allowed the elaboration of a set of proposals presented to the Government. The table below describes the revision proposals and the suggestions not adopted in this document regarding incentives for the acquisition of a plug-in hybrid vehicle:

Table 1 - Proposed revisions from green taxation reform

Proposed revisions	
1	Introducing a limit to depreciable amount of € 50,000 (acquisition cost or revalued amount), higher than the one applied to other vehicles, from which personal income tax and corporate income tax depreciation is not accepted as a tax expense

2	Reduce by 50% autonomous taxation rates applicable to personal income tax and corporate income tax to the deductible charges with hybrid passenger cars plug-in
3	Increased motor tax rates due to CO2 emissions
4	Possibility of deduction of VAT on the purchase, manufacture or import, rental, use, processing and repair of electric or hybrid passenger cars plug-in
5	Reintroduction of the tax incentive for car scrappage
Not adopted suggestions	
1	Non-application of autonomous taxation to passenger vehicles, in corporate income tax and personal income tax, on the depreciation component not fiscally accepted
2	Accepting as tax expense, in corporate income tax and personal income tax, the over-limit depreciation of plug-in hybrid and natural gas passenger cars

Table 6 begins by presenting a measure, which was subsequently approved, that introduces an increase in the limit of the overall amount of depreciation per plug-in hybrid vehicle (note that the remaining vehicles are subject to a limit of € 25,000, half as possible for plug-in hybrid vehicle [3]). Changes to autonomous taxation and motor tax will be described in more detail in the following points. The table also shows two other proposals: the possibility of VAT deduction of various expenses related to plug-in hybrid vehicle and the reintroduction of an incentive to scrappage[4].

The second part of the Table shows two not adopted suggestions of incentives for the acquisition of plug-in hybrid vehicle, which give us a clue about possible alternatives that were not followed. The commission shows that the non-application of the autonomous taxation to not accepted depreciation expenses by the tax authorities and not considering a limit to them were considered.

[3] Ordinance No. 467/2010, of July 7th, then amended by the "Green Taxation Law"
[4] Artº.25, nº1, al. B) of the Administrative Rule no. 467/2010, of July 7

In subchapter 2.2 we could see, in addition to the motivations for the creation of the green taxation system, not adopted suggestions which focused mainly on the depreciation of plug-in hybrid vehicle. However, in order to get a clear idea of possible alternatives to the incentives provided by the green taxation system, it will be necessary to understand what other countries have done at this level.

Turning to the green tax reform bill, the commission says that "the importance of reforms of the fiscal system ensuring the balance of public accounts and sustainable growth has been reiterated by the European Union (EU)", will which had recently been highlighted in the conclusions of the European Council of 28-29 June 2012: "fiscal policy should contribute to fiscal consolidation and sustainable growth". This fact proves that the route for green taxation system in Portugal has mainly European bases. Although the green tax reform only appears in Portugal in 2014, in 2012 several European countries had already implemented measures to encourage the purchase of green vehicles. Although incentives to plug-in hybrid vehicle are not an option for all European Union countries, incentives to purchase electric vehicles proliferate.

2.5 Green Taxation Framework: Impact on Autonomous Taxation and Using Costs

Autonomous taxation contradicts the logic of main corporate taxes in Portugal, since it appears as a special tax on some business expenses and not on its incomes. Introduced by Decree-Law no. 192/90, of June 2, autonomous taxation emerges with the intention of the legislator to penalize the taxation of undocumented expenses incurred by companies.

Under green tax reform, and through the amendment of environmental tax rules, changes are created in several tax codes[5]. At corporate income tax code level, the changes

[5] CIRS, CIRC, CIVA, CIMI, CISV, CIEC and EBF

appear in art. 73, in the definition of a spin-off operation, and in art. 88th, on autonomous taxation. The table below compiles the autonomous taxation changes introduced by the green taxation:

Table 2 - Changes introduced by green tax reform in autonomous taxation

Introduction of nº17 of art. 88th	Reduction by half of the autonomous taxation to plug-in hybrid vehicle rates to, respectively, 5%, 10% and 17.5%
Introduction of nº18 of art. 88th	Reduction by half of the autonomous taxation rates for light passenger vehicles powered by gas or natural gas for respectively 7.5%, 15% and 27.5%

As we can see, there is a reduction of autonomous taxation, for plug-in hybrid vehicle, of 50% in the rates originally applied to most passenger cars. In this aspect, it must be taken into account that the plug-in hybrid vehicle has a particularity compared to conventional hybrids. Despite having an electric motor and an internal combustion engine, the plug-in hybrid vehicle distinguishes themselves from other hybrids by the susceptibility of charging the electric motor battery directly from an outlet, while conventional hybrids do it via the internal combustion engine (while in motion). Thus, the concept of plug-in hybrid vehicle is stricter than the concept of hybrid vehicle.

This amendment creates an incentive to use this type of vehicles, which in turn are also fuel economizers. Starting from a price per liter of diesel of 1,25 €, it is possible to perceive this reality from the average consumption every 100km. The table below compiles information on the fuel cost and consumption of three Toyota vehicles:

Table 3 - Using costs: comparing the Avensis, Prius and Auris (www.toyota.pt)

Car Model	Description	Fuel type	Consumption 100km	Consumption 15,000km	Fuel cost	Autonom. Taxation	Total Cost
Avensis	2.0 D-4D (143cv)	Diesel	4,2	630	787,50 €	275,63 €	**1.063,13 €**
Prius Plug-in	1.8 Híbrido Plug-in (136 cv)	Diesel/Electric	2,1	315	393,75 €	68,91 €	**462,66 €**
Auris	1.6 D-4D (112cv)	Diesel	3,4	510	637,50 €	175,31 €	**812,81 €**

We can see that the Prius Plug-in model is not only subject to lower taxation but is also cheaper in terms of fuel consumption. The Toyota Avensis spends more than the double to make 15,000km and savings, compared to a low-end model (Auris), are considerable.

However, taxation at autonomous taxation level can be avoided by companies. In view of the huge increase in autonomous taxation rates on vehicle costs, the possibility of entering into a written contract that imputes the vehicle to the employee using was a very well publicized option.

2.6 Green Taxation Framework: Impact on Vehicle Tax and Purchase Costs

After seeing the financial incentives provided by autonomous taxation to the use of plug-in hybrid vehicle, it is also necessary to understand the incentives given when purchasing these vehicles. In addition to the single circulation tax, the purchase of vehicles is also mainly subject to motor tax and VAT.

Like the corporate income tax, motor ax also changed with the entry of green tax reform. This increased the rates of motor tax code, Article 7, tables A, B and C, as it also introduced feebates for the acquisition of various types of vehicles. Among them is one concerning the acquisition of plug-in hybrid vehicles, which reduces generic rates to only 25% of their value[6].

For these reasons, it is necessary to understand the true weight of this incentive provided by motor tax. The table below displays a simulation that seeks to determine the amounts paid under motor tax, given the sale price and the changes made by the green taxation system:

[6] artº.8, nº1, al. d)

Table 4 - Purshasing costs: comparing the Avensis, Prius and Auris (www.toyota.pt)

Car Model	Description	Basic Value	Cylinder capacity (in cubic centimeters)	Rates per cubic centimeters	Plot to be cut	Motor tax (cm3)
Avensis	2.0 D-4D (143cv)	22.983,70 €	2.000	4,84 €	5.362,67 €	4.317,33 €
Prius Plug-in	1.8 Híbrido Plug-in (136 cv)	28.005,36 €	1.800	4,84 €	5.362,67 €	837,33 €
Auris	1.6 D-4D (112cv)	18.306,28 €	1.600	4,84 €	5.362,67 €	2.381,33 €

Car Model	CO2 level (in grams per kilometer)	Rate on gram per kilometer	Plot to be cut	Motor tax (CO2)	Motor tax	VAT	Sale value
Avensis	108	68,58 €	6.228,00 €	1.178,64 €	5.495,97 €	6.550,32 €	35.030,00 €
Prius Plug-in	49	5,00 €	380,00 €	-33,75 €	803,58 €	6.433,47 €	35.435,00 €
Auris	89	20,30 €	1.600,00 €	206,70 €	2.588,03 €	4.805,69 €	25.700,00 €

The table shows, in first instance, the engine dimension component in the motor tax calculation. Although they have similar motor dimensions, the intermediate rate of 25% ends up favoring the Prius Plug-in immensely. In turn, the environmental component of the plug-in hybrid vehicle is negative, so low are its emissions. It is, however, also reduced to 25% the benefit that comes from it.

As we have seen in section 2.2, the introduction of the environmental component (CO2 emissions) is also introduced by the green taxation reform. The feebate introduced, lowering the amount of motor tax paid to just 25%, is supposed to be more capable of having an effect on hybrid purchase (Hirte & Tscharaktschiew, 2013). However, despite the tax benefits attributed to the Prius Plug-in, it cannot be said that the vehicle becomes a cheap car. The Avensis, being a more spacious, robust and powerful car, costs the same. At his turn, the Auris, from a lower and relatively less powerful range, is considerably cheaper (around € 10,000).

It follows that the introduction of the green taxation system makes plug-in hybrid vehicle cheaper via motor tax. Still, the plug-in hybrid vehicle has the price of a high-end vehicle, which highlights the costs of developing and acquiring such technology.

2.7 The plug-in hybrid vehicle market in Portugal

We have verified that, with the green taxation reform, several tax incentives were created for the use and acquisition of plug-in hybrid vehicle. We must then seek to know more about the market development for these vehicles in Portugal.

Although there is no data after the application of Law n. º 82-D/2014, of December 31, relating to the sale of plug-in hybrid vehicle, there is a document published by the commission for green tax reform in 2013 that compiles a series of statistics on the Portuguese car market where it is possible to find data on the sale of hybrid vehicles between the years of 2000 and 2012. As there is no information on the sale of plug-in hybrid vehicle exclusively, the evolution of the national hybrids market can help us to better understand the reality of its integral part, the plug-in hybrid vehicle market:

Table 5 - Sales of hybrid vehicles in Portugal (ACAP, 2013)

Marca	2007	2008	2009	2010	2011	2012	Total
Honda	1484	1117	789	788	381	176	6287
Toyota	350	490	286	551	340	277	2750
Lexus	80	85	68	67	192	58	629
Peugeot					10	280	290
Porsche				60	52	40	152
Mercedes						81	81
Citroen						58	58
Mercedes			8	16	8	2	34
Opel					1	12	13
Chevrolet					1	5	6
BMW				2	1	2	5
Audi						5	5
Total	1914	1692	1151	1484	986	996	10310

As we can see in the table, the sale of hybrid vehicles increases considerably until 2007, year in which the maximum sales occurred for the period considered. Although the diversity of brands to provide this type of vehicle has increased, sales later break up to around 1000 units in the last 2 years considered, 2011 and 2012. Yet, we can still verify that hybrid vehicle sales represent a residual value in total passenger car sales:

Table 6 - Percentage of hybrid in all car sales in Portugal (ACAP, 2013)

	2007		2008		2009		2010		2011		2012	
	Units	**%**	**Units**	**%**	**Units**	**%**	**Units**	**%**	**Units**	**%**	**Units**	**%**
Gasoline	60148	29,8%	63767	29,9%	52263	32,5%	72018	32,2%	44563	29,0%	26221	27,5%
Diesel	139598	69,2%	147799	69,3%	107115	66,6%	148947	66,7%	106884	69,7%	67314	70,6%
Hybrid	**1914**	**0,9%**	**1692**	**0,8%**	**1151**	**0,7%**	**1484**	**0,7%**	**986**	**0,6%**	**996**	**1,0%**
Electric	0	0,0%	0	0,0%	0	0,0%	18	0,0%	203	0,1%	65	0,1%
Gasoline /GPL	35	0,0%	33	0,0%	418	0,3%	932	0,4%	768	0,5%	680	0,7%
GPL	5	0,0%	3	0,0%	0	0,0%	0	0,0%	0	0,0%	33	0,0%
Total	201700		213294		160947		223399		153404		95309	

We see, therefore, that hybrid vehicles sale percentages have remained low in the years under consideration, reaching 1% of total light vehicles sold in 2012. Since plug-in hybrid vehicle represent only a part of this small market share, we realize that these vehicles are not very commercialized. However, spite of helping us realizing how low total hybrid sales are in Portugal, these statistics cannot say anything about the effect of the created green tax system.

2.8 Feebate Systems

As we can see, autonomous taxation came mainly with the objective of taxing expenses that are presumed not to have a business character. However, the green tax reform introduces, among others, reduced rates for plug-in hybrid vehicle expenses and an intermediary rate in motor tax. There are previous studies that have looked at similar issues, creating basis for this work.

The system of incentives created in autonomous taxation and motor tax for plug-in hybrid vehicles, as we can see in table 1, combines a history of rate worsening for diesel and gasoline vehicles with a reduced rate for the acquisition of plug-in hybrid vehicle. This system is thus similar to the feebate, widely used in encouraging the reduction of carbon emissions. Under this scheme, charges are levied on polluting producers while the non-polluting ones are subsidized, have access to tax benefits or a reduced rate. The feebates have been used primarily to stimulate the growth of green

energy production when the acquisition of new technologies and implementation costs are particularly high (PricewaterhouseCoopers LLP, 2008).

At automobile market level, this fiscal practice offers several advantages over taxation based on savings or fuel standards (Johnson, 2007). Public acceptance, the possibility of associating feebates with a particular type of vehicle, and the potential of this practice in driving car purchase decisions are examples (Greene, Patterson, Singh, & Jia, 2005). Therefore, these studies imply expecting that the tax reform have a good chance of positively influence plug-in hybrid purchase.

3 Empirical Research

3.1 Methodology

The target population defined for the study covers all persons holding a driving license and driving light passenger vehicles. In this way, we intend to understand if access to financial incentives, introduced by the green tax reform, along environmental awareness, technology, oil producer's independence, image factors and several social economic factors, such as vehicle size, residence, income, household size and education level, explain the interest for plug-in hybrid vehicles, hence highlighting the possible effect of green tax systems on the behavior of most vehicle buyers.

In order to carry out the study, questionnaire survey method was chosen. The questionnaire was elaborated in the sense of being the respondent himself to respond, so of direct administration, which pays in favor of the content of confidentiality and obtaining true intentions or opinions (Quivy & Campenhoudt, 1998). Most of the questions are made with a retrospective intention, as they attempt to ascertain the opinion already formed by the respondents and certain practices that they may or may not have developed in their recent past, making it less biased and easier to obtain results (Glass &

Arnkoff, 1997); (Schwarz, 1999). Even when this is not the case, the questions are always close-ended. The presentation of a list of closed answers excludes the possibility of respondents reporting activities / data that are not useful for the investigation at hand, allowing even better clarification of what is intended in the question, which also favors the reliability of the obtained data (Schwarz & Hipper, 1991); (Schwarz, 1999).

The questionnaire survey is divided into three parts. As first step, the questionnaire seeks to assess the interest of vehicle owners for plug-in hybrid vehicle and what is the ownership of the vehicle they currently drive, whether if individual or business owned. The second phase of the questionnaire deals with the factors justifying interest in plug-in hybrid vehicle found in the literature: environment, technology, image, independence of oil producers and access to financial incentives. At this stage, the questionnaire is deployed in questions for individual and business users, with adaptations to the context and reality of each of these groups (the incentive provided by autonomous taxation is only addressed in questions for business users, for example). The questions seek, in a first phase for each factor, to verify if the respondents recognize the mentioned characteristics of the plug-in hybrid vehicle. Already in a second phase, for each factor, the questions seek to identify how much the respondent values these characteristics, returning the frequency with which they usually develop actions that mirror them, such as recycling, the frequency with which they acquire new Technologies, among others. This logic is important especially since only when the respondent recognizes the characteristics of the plug-in hybrid vehicle and values them, simultaneously, it is expected that the purchase of a plug-in hybrid vehicle will become more interesting. The respondent may have huge environmental concerns, but not recognize the plug-in hybrid vehicle as an environmentally friendly vehicle, for example. Questions regarding the interest in

acquiring a plug-in hybrid vehicle are placed prior to the deployment, since completing the survey may influence the responses to them (Brace, 2008).

The questionnaire continues with general and personal questions asking for respondents age, salary, household size, education and the current vehicle they drive. There are clues in the literature that reveal potential relationships between these indicators and the willingness to acquire a plug-in hybrid vehicle. Even on web-based questionnaires, such questions (Brace, 2008), if placed at the beginning, are perceived to be me more intrusive.

The method chosen to develop the statistical study was the confirmatory factor analysis, carried out with SPSS and AMOS software, in order to confirm, in the general population, the factor structure obtained in previous exploratory analysis. This analysis, its model and base sample will be developed in subsequent chapters.

3.2 Descriptive Analysis

3.2.1 Individual Users Sample

The sample of individual users collected 177 respondents. The sample is relatively diverse, with individuals of different income levels, who live in different districts of the national territory, in order to become representative of the national context:

Table 7 - Individual users sample descriptive

Gender	**N**	**%**	**Education**	**N**	**%**
Male	101	57,1%	Basic school	1	0,6%
Female	75	42,4%	Secondary school	57	32,2%
Total	177		Degree	79	44,6%
Net monthly household income	**N**	**%**	Master	39	22,0%
0-1000€	24	13,6%	PHD	1	0,6%
1000-2000€	64	36,2%	**Total**	177	
2000-3000€	57	32,2%	**Household size**	**N**	**%**
3000-4000€	18	10,2%	1	16	9,0%
>4000€	14	7,9%	2	24	13,6%
Total	177		3	60	33,9%

Residence	N	%
Aveiro	4	2,3%
Braga	7	4,0%
Coimbra	7	4,0%
Faro	1	0,6%
Guarda	3	1,7%
Leiria	4	2,3%
Lisboa	42	23,7%
Madeira	3	1,7%
Porto	30	16,9%
Santarém	1	0,6%
Setúbal	4	2,3%
Vila Real	8	4,5%
Viseu	63	35,6%
Total	177	

4	59	33,3%
5	13	7,3%
6	4	2,3%
8	1	0,6%
Total	177	

3.2.2 Business Users Sample

The sample made of business users counted on only 30 respondents, although the investigation had run for some months, and of having been promoted vast contacts along national companies. The sample is also diversified, although having few representative cases of each one of the indicators:

Table 8 - Business users sample descriptive

Gender	N	%
Male	25	83,3%
Female	5	16,7%
Total	30	
Net monthly household income	**N**	**%**
0-1000€	4	13,3%
1000-2000€	10	33,3%
2000-3000€	7	23,3%
3000-4000€	6	20,0%
>4000€	3	10,0%
Total	30	
Residence	**N**	**%**
Bragança	1	3,3%
Castelo Branco	1	3,3%
Coimbra	1	3,3%
Leiria	1	3,3%

Education	N	%
Basic school	0	0,0%
Secondary school	14	46,7%
Degree	11	36,7%
Master	3	10,0%
PHD	2	6,7%
Total	30	
Household size	**N**	**%**
1	2	6,7%
2	7	23,3%
3	6	20,0%
4	10	33,3%
5	4	13,3%
6	1	3,3%
Total	30	

Lisboa	1	3,3%
Madeira	2	6,7%
Porto	8	26,7%
Setúbal	1	3,3%
Viseu	14	46,7%
Total	30	

3.3 Suitability and reliability tests

3.3.1 Individual Users Sample

To see if it is adequate to carry out the factorial analysis, it was necessary to check if there was a sufficient number of answers for each level of the Likert scale considered in the different questions. This value is defined as the STV (subject-to-variables) ratio, and several authors define reference values. (Garson, 2008) indicates 10 as an ideal value for STV, while (MacCallum, Widaman, Zhang, & Sehee, 1999) suggest a value of 5. Thus, we chose to aggregate the responses of levels that were chosen by less than 5 people, with care not to join at the same level responses that demonstrate completely different intensities. There was not aggregated any "disagree" with "agree", for example. For this reason, some levels of response were not aggregated although they were not chosen by more than 5 respondents.

Then, using the SPSS, the KMO measure and the Bartlett's test for sphericity were obtained (only with answers to questions used constructing the model):

Table 9 - KMO and Bartlett's Test for individual sample

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,784
Bartlett's Test of Sphericity	Approx. Chi-Square	2353,446
	Df	486
	Sig.	,000

It can be verified with the Bartlett's test that the sample data have a normal multivariate distribution. However, the test is sensitive to deviations from the assumption

of normal distribution of variables and, for large samples, tends to reject the null hypothesis even when correlations are small (Snedecor & William, 1989). In turn, the KMO measure tells us that the level of correlations between variables is on the threshold between the mean (0.7-0.8) and the good (0.8-0.9). The two tests therefore point to the existence of correlations between the variables, making feasible the factorial analysis for this sample, although some of the levels have a relatively low frequency of responses. This exercise was manly worked out in order to offer guidelines for sample adequacy to confirmatory factor analysis.

To measure reliability of the variables we performed Cronbach's Alpha, obtaining the following results:

Table 10 – Cronbach's Alpha for individual sample

Reliability Statistics

Cronbach's Alpha	N of Items
,846	25

The results show a value of 0.846 for Cronbach's Alpha, which is considered to be a good value according to reference values (Gliem, 2003):

Table 11 – Cronbach's Alpha reference values

Alpha's value	Internal consistency
>0,9	Excelent
0,8-0,9	Good
0,7-0,8	Aceptable
0,6-0,7	Questionable
0,5-0,6	Poor
<0,5	Inaceptable

3.3.2 Business Users Sample

Proceeding in the same way for the business sample, several problems arise, above all in the STV ratio. For example, in response to question 10 of the business questionnaire,

all 30 respondents believed that plug-in hybrid vehicle represented a new technology, so this question had to be subtracted from the study. Likewise, in response to the various sub-points of question 13, almost all respondents agree or fully agree that conducting a plug-in hybrid vehicle allows access to the various incentives, so these issues have also been withdrawn in order to enable analysis. In question 5, only 3 individuals state that the company for which they work is not environmentally responsible, which creates enormous constraints to the analysis. This question is therefore also withdrawn. Likewise, in the process of adding the levels of answers that were not an option for 5 more respondents for the other questions, we found a large number of cases with a lack of answers, especially in the disagreement with some of the statements. After performing these steps, we obtain the following table in SPSS:

Table 12 - KMO and Bartlett's Test for business sample

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,507
Bartlett's Test of Sphericity	Approx. Chi-Square	596,749
	Df	325
	Sig.	,000

Once again, the Bartlett's test suggests that the sample data have a normal multivariate distribution. However, the KMO measurement is at a level between 0.5 and 0.6, within the limit of what is acceptable for conducting the factorial analysis, revealing some limitations in sample size.

As for individual sample, reliability of the variables was measured by Cronbach's Alpha:

Table 13 - Cronbach's Alpha for business sample

Reliability Statistics

Cronbach's Alpha	N of Items
,925	30

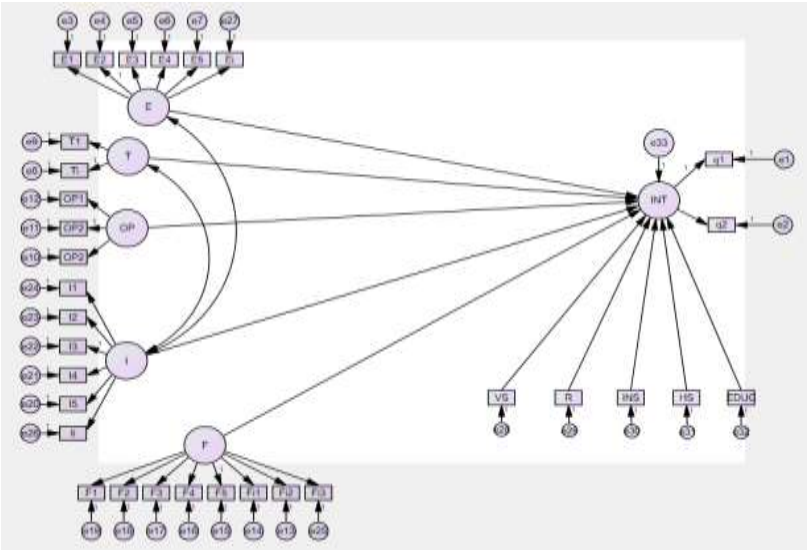
Cronbach's Alpha, for the business sample, show an excellent result according to reference values (Gliem, 2003).

3.3.3 Individual Model Description

The main purpose of this study is to confirm if the structure of factors identified in the literature, among which is the access to financial incentives (introduced in 2014 in Portugal), recognizes what can initiate the process of acquisition of a plug-in hybrid vehicle in the majority of people. For this reason, the model must be able to measure if green taxation can trigger plug-in hybrid acquisition.

A structural equations model was created that will use the SPSS numerical data. The drawing obtained for the individual sample was as shown:

Figure 1 - Individual Base model



As suggested in the literature, aspects like vehicle size (VS), residence (R), income (INS), household size (HS) and education level (EDUC) were also taken into

account in order to obtain greater explanatory power. The inclusion of these variables increased the values of the variance explained in the previous exploratory factorial analysis. In addition to the factor influence relationships in the interest to acquire a plug-in hybrid (INT), correlations between factor image (I) and factors Technology (T) and Environment (E) were also considered. When drivers use a plug-in hybrid vehicle, they may wish to convey the image of being environmentally responsible or of being an adept of new technologies. Factor I issues incorporate this logic, so it will be more realistic to consider the existence of this correlation in the model.

The INT factor is composed by the answers to the first and second questions. It is therefore considered in this composition not only the interest shown in the purchase of the last vehicle, but also a temporal factor (the green taxation system only came into force in 2014), introduced by question 1. The table below matches the survey questions with the model factors:

Table 14 - Factors to questions: individual sample

Factors	Description	Questions	Factors	Description	Questions
E	Environmental awareness	4 5	**VS**	Vehicle size	22
OP	Independence from oil producers	6 7	**R**	Whether or not you reside in a large center (Lisbon or Porto)	23
I	Image	8 9	**INS**	Income Scale	20
T	Technology	10 11	**HS**	Household size	19
F	Access to financial incentives	12 13	**EDUC**	Education level	21

3.3.4 Business Model Description

The model for the business sample was drawn up with the same literary basis as the model for the individual sample. However, the business sample is very small. Several errors related to the constructs show negative variances. Also, model fit indicators, despite

almost any change, remain far away from acceptance values, what suggests that the discrepancy between data and model specification is too high. That translates in the impossibility to obtain a trustful result when developing the model. For those reasons, the business analysis cannot be performed.

4 Results analysis

4.1 Model Fit

4.1.1 Individual Model

Before starting the analysis of the factor estimation results, it is necessary to understand if model fit is adequate for the used data. When running the test for the described model, AMOS returns several measures that are intended to accurately measure the model f it. To evaluate the adequacy of the model, the values of CMIN / DF, RMSEA, GFI, AGFI and RMR were taken into account, for which the literature indicates references of its interpretation. GFI and AGFI range from 0 to 1, the higher the values of both the better. (Byrne, 1994) states that in order to accept a model, its GFI and AGFI must exceed 0,9 and the CMIN / DF value less than 3. In turn, (Hu & Bentler, 1999) indicate that the RMSEA should not exceed 0.06 and the RMR 0.08. The execution of the test in AMOS returns the message "minimum was achieved", which means that the estimation process generated a permissible solution (Lemke & Fachel, 2005), with the following indicators for the model fit:

Table 15 - Model fit indicators for base model

Model Fit indicators	CMIN/DF	RMSEA	GFI	AGFI	RMR
Model values	2,488	0,092	0,711	0,668	0,157
Reference values	<3	<0,08	>0,9	>0,9	<0,08

As we can verify by observing the table, the model shows only an acceptable value for CMIN / DF, while RMSEA returns a mediocre suitability. The remaining three items seem to be a bit far from accepting the adequacy of the model, especially GFI and AGFI. Through modification indices, AMOS gives us clues to improve these indicators. These

suggestions are offered by software packages and serve to guide the data according to a new model that will probably improve model fit (Harrington, 2009). However, it is not acceptable to add all modifications to the model in factorial analysis. A modification, to be added to the model, must have a theoretical and realistic support (Simsek, 2007). Considering these aspects, we observe the modification indices suggested for the covariances between produced errors. Here, we found evidence for the existence of a correlation between items F3 and F4, as well as between Fi2 and Fi3:

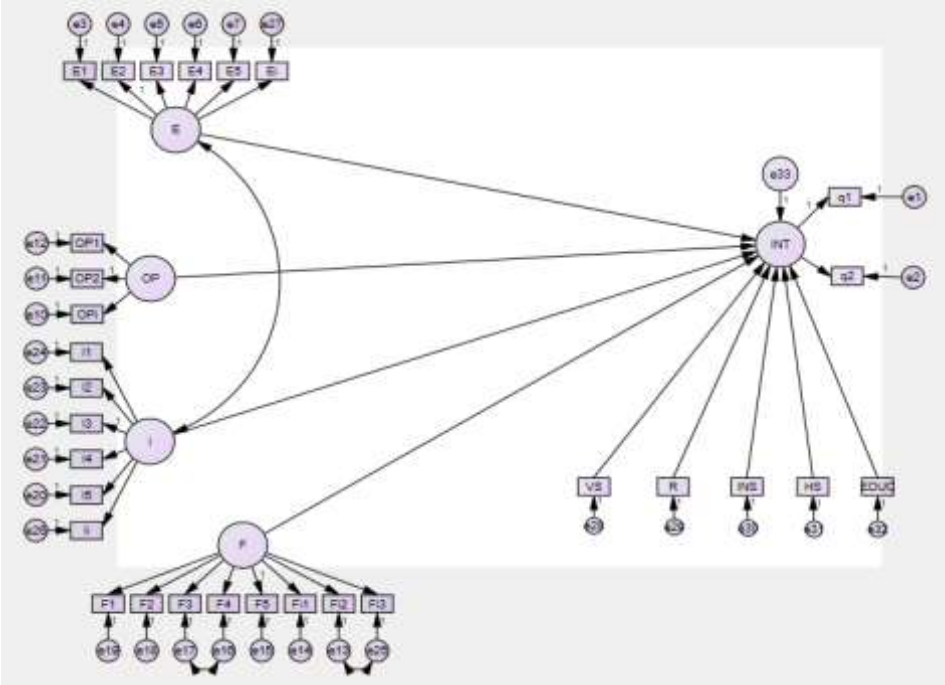
Table 16 - Modification indices

Cov	M.I.
e13<-->e25	52,117
e16<-->e17	36,591

There are some other values of M.I. greater than 10, value that suggests the existence of other covariances between error constructs (Byrne, 2001), but only in these cases this relationship is justified. These items refer to the incentives granted in the purchase of a plug-in hybrid vehicle, to the feebate rate and the environmental factor, considered in the motor tax calculation. They are, in essence, only slightly different in shape, both having motor tax seat and therefore being administered in the purchase of the vehicle. For these reasons, it will not be unrealistic to actually consider the existence of a link between the errors of those constructs. In addition to the suggestions provided by the modification indices, the constructs e8 and e9 produce a negative variance, affecting the estimation produced by the model. Thus, the technology factor was removed from the model as well.

An adjusted model was then created, with the correlations suggested by the modification indices and the subtraction of the technology factor, as shown in the figure:

Figure 2 - Individual modified model



This new model also produces new values to measure the Model Fit, which are compiled in this table, compared to previously obtained results:

Table 17 - Model fit comparison: Base model and Modified model

Model Fit indicators	CMIN/DF	RMSEA	GFI	AGFI	RMR
Base model values	2,419	0,090	0,719	0,677	0,108
Modified model values	2,071	0,078	0,753	0,714	0,102
Reference values	<3	<0,08	>0,9	>0,9	<0,08

We found that there was an improvement in GFI and AGFI values. However, these are still far from recommended values. The CMIN / DF has an even more acceptable value than in the first model, while the RMSEA reaches a favorable value. Finally, the RMR does not suffer great oscillation and is still unfavorable about Model Fit. However, as mentioned, these values are only guidelines for the development of factorial analysis. For example, in an area where previous models have produced GFI values of only 0.7, a GFI of 0.85 is considered to be progress and should therefore be accepted (Bollen, 1989).

For this work, there are no reference GFI values, since the authors cited in the literature chapter, and the most referenced studies in the area only develop exploratory

factorial analyzes. In addition, this measure is sensitive to the size of the sample. We can thus consider that the fit of the model is reasonably acceptable.

4.2 Results of the Confirmatory Factorial Analysis

4.2.1 Individual Sample

In the estimates section the AMOS returns the estimates of the relations contained in the model. Taking the first step in the base model, the table below compiles the (non-standardized) estimates obtained for the relations between factors:

Table 18 - Estimates for the base model

			Estimate	S.E.	C.R.	P-value
INT	<---	F	0,257	0,097	2,64	0,008
INT	<---	OP	0,055	0,107	0,515	0,607
INT	<---	T	0,019	1,715	0,011	0,991
INT	<---	E	0,043	0,174	0,244	0,807
INT	<---	I	0,228	0,225	1,013	0,311
INT	<---	VS	0,144	0,146	0,986	0,324
INT	<---	R	0,07	0,143	0,488	0,626
INT	<---	INS	0,026	0,074	0,35	0,726
INT	<---	HS	0,021	0,064	0,321	0,748
INT	<---	EDUC	0,031	0,149	0,206	0,837

The table shows that only the F factor (access to financial incentives) shows a (non-standardized) regression coefficient that is statistically significant. The results for the model obtained after reading the modification indices do not change this situation. Still, the vehicle size becomes statically significant:

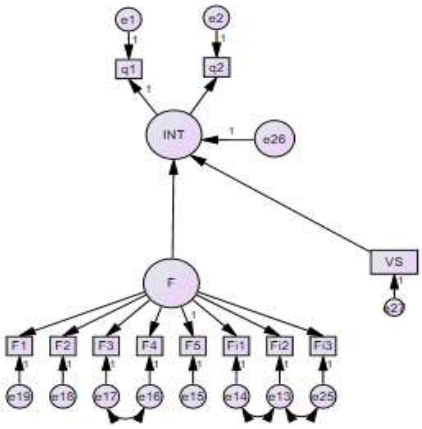
Table 19 - Estimates for modified model

			Estimate	S.E.	C.R.	P-value
INT	<---	F	0,199	0,089	2,245	0,025
INT	<---	OP	0,121	0,104	1,168	0,243
INT	<---	E	0,046	0,139	0,327	0,744
INT	<---	I	0,164	0,132	1,247	0,212
INT	<---	VS	0,266	0,144	1,845	0,065
INT	<---	R	-0,022	0,131	-0,17	0,865
INT	<---	INS	0,032	0,069	0,459	0,646
INT	<---	HS	0,024	0,059	0,4	0,689
INT	<---	EDUC	0,064	0,138	0,463	0,644

4.2.2 Simplified Model

As we have seen in previous chapters, only two of the factors are statistically significant on their effect over interest. This means that a large number of constructs and variables do not add explanatory power, creating some discrepancy between the data and the specified model. Thus, we chose to create a model with only the factor of access to financial incentives and the size of the vehicle that the respondent leads (the only ones for which we find statistical significance). The template specified in AMOS returns the following drawing:

Figure 3 - Simplified model



It was considered a covariance arrow between errors e13 and e14, related to the importance attributed by drivers to access to car scrapping schemes and the feebate of motor tax rates, through suggested modification indices:

Table 20 - Modification indices

Cov	M.I.
e13<-->e14	16,791

Analyzing now the model fit of this simplified version, we obtain the comparison between the indicators of the several models:

Table 21 - Model fit comparison

Model Fit indicators	CMIN/DF	RMSEA	GFI	AGFI	RMR
Base model values	2,419	0,090	0,719	0,677	0,108
Modified model values	2,071	0,078	0,753	0,714	0,102
Simplified model values	2,794	0,101	0,901	0,836	0,062
Reference values	<3	<0,08	>0,9	>0,9	<0,08

In the table, we see that there is a significant improvement in AGFI, GFI and RMR values, the last two values reaching acceptability. The RMSEA value increases slightly, however this indicator tends to favor models with higher number of parameters. Taking into account that this simplified model was obtained after suppressing a considerable part of model parameters, the negative effect on the RMSEA was expected. Although the ideal is that this value is below 0.08, it is also possible to accept a model provided that this value does not exceed 0.1 (Browne & Cudeck, 1993). The value of CMIN/DF slightly deteriorates, although it remains with an acceptable value.

The results of this simplified model are consistent with those of other two models, maintaining the statistical significance and positive effect of access to financial incentives and car size on interest for plug-in hybrids:

Table 22 - Estimates of simplified model

			Estimate	S.E.	C.R.	P-value
INT	<---	F	0,267	0,096	2,793	0,005
INT	<---	VS	0,246	0,141	1,74	0,082

4.2.3 Robustness Tests

Following the analysis of the base models, a set of tests was carried out to complement the results obtained in the previous chapters. First, a number of non-parametric tests were carried out to determine whether the incentive requested (question 16) was sensitive to household size, vehicle size, level of education, income (net monthly) and place of residence (if resident in a big or small city). The Mann-Whitney test was used in cases where there were only 2 levels of response, whereas the Kruskal-Wallis test was used in cases where there were more than 2 levels of response:

Table 23 - Test results by individual sample division

Division criteria	Tests		P-value
	Kruskal-Wallis	Mann-Whitney	
Household size	x		0,106
Vehicle size		x	0,389
Education level	x		0,968
Net monthly income	x		0,214
Place of residence		x	0,505

As we have seen, we can only accept that the incentive requested is sensitive to the household size at a significance level of 11%. The following table compiles the requested incentive average per household size level:

Table 24 – Mean of requested amount by household size

Household Size	Mean		N	Std. Deviation
1	8437,44		16	7730,607
2	8000,00		24	5366,968
3	6591,67		60	4694,210
4	10259,75		59	8218,577
5	9230,77		13	8156,325
6	20250,00		4	17423,643
8	12000,00		1	
Total	8705,22		177	7330,262

There seems to be an increased incentive request for families with more than 3 elements. The Mann-Whitney test was then performed for a sample divided into families with 3 or less elements and families with more than 3 elements. The SPSS returns a p-value for this test of 0.018, thus rejecting the hypothesis of equality of distributions in both populations. This reinforces the idea that the size of the household influences the amount of incentive requested.

Returning to the results of the models, both revealed a significant relationship between access to financial incentives and interest in plug-in hybrid vehicle. However, it is also important to note whether this relationship exists in the general population, or whether it is in turn influenced by factors such as income or residence. Thus, the samples

were divided by several criteria and, again using AMOS, we tested several times the new model. Samples were never divided into more than two levels for the different criteria, since a considerable number of responses were required to perform the CFA. The following table shows the results of the estimated regression coefficients between the F and INT factors:

Table 25 - P-values of factor F

Householde size		
	≤3	>3
P-value	0,038	0,081
Coeficient	0,128	0,203
Vehicle size		
	Small	Big
P-value	0,02	0,322
Coeficient	0,189	0,084
Education level		
	Ungraded	Graded
P-value	0,419	0
Coeficient	-0,088	0,214

Monthly net household income		
	≤2000€	>2000€
P-value	0,07	0,403
Coeficient	0,166	0,4
Residence		
	Big city	Small city
P-value	0,025	0,459
Coeficient	0,199	0,064

For ungraded respondents from small towns, with incomes above 2000 € and driving large individual vehicles, the coefficient between factors F and INT is not statistically significant. The fact that financial incentives do not have a significant effect on plug-in hybrid vehicle interest among individuals from smaller cities and larger vehicles is consistent with the literature. The level of training may also influence the ability to truly understand incentives. On the other hand, the coefficient has a greater magnitude when the sample is reduced to only graduated respondents, and is positive whenever significant along the various criteria of dividing the sample.

At last, question 16 of the questionnaire aims to measure the incentive amount required by drivers to opt for a plug-in hybrid rather than a conventional vehicle. The study of this response becomes particularly important in order to understand whether if

drivers attribute a value to the characteristics of these vehicles and if the created green tax system concedes an amount capable of influence people´s choices. A T-test was carried out at the mean of the incentive required to opt for a plug-in hybrid:

Table 26 – Required incentive amount mean T-test

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Incentive16	15,800	176	,000	8705,220	7617,85	9792,59

The table shows that the interval defined for average, with 95% certainty, is between 7617.85 € and 9792.59 €, being this last one already very close to the price difference between the conventional vehicle and the plug-in hybrid. Being the average of 8705.22 €, all values are much higher than that attributed by the created green tax system.

5 Conclusions

This study aims to access the effect of Portuguese tax policy on vehicle buyers purchase options, specifically for plug-in hybrid vehicles. Previous studies, as of Ritsuko & Sevastyanova (2011) or Krupa, et al., (2014), suggested that several factors underlie this option, including precisely tax related incentives. From Ritsuko & Sevastyanova (2011) framework, although with several adaptations, an empirical model was developed that was intended to estimate the effect of the various factors on the interest for plug-in hybrid vehicles acquisition. The scope considered for the study was also broadened to understand whether the green taxation introduced in Portugal was effective in shaping general population intentions towards green taxation, not just a sample of plug-in hybrid vehicle buyers.

The base model displays the factors found in literature and measured by the questionnaire survey. The model revealed a positive and significant effect of financial

incentives over the interest for plug-in hybrid vehicle, not confirming, however, the existence of a relation between environmental awareness, technology, oil independence, image, place of residence, level of education and household size, and the interest for a plug-in hybrid. Nevertheless, this model drawn from existent literature exhibits a poor fit, revealing that there is some discrepancy between the specified model and the sample data. Therefore, a second model (modified model) was created by excluding the technological factor, and reaffirmed the presence of a positive effect of access to financial incentives in the interest for plug-in hybrid vehicles, also adding a positive effect between the size of the vehicle that respondents currently drive and the interest for plug-in hybrids, which is in part contradictory with the conclusions of Ritsuko & Sevastyanova (2011), Krupa, et al., (2014), Deloitte Consulting LLP (2010) and Hidrue, Parsons, Kempton & Gardner (2011) studies. The expectation is that drivers of smaller vehicles have a greater interest in plug-in hybrids, while this study leads to the opposite conclusion. Still, it seems that the size driven vehicle, in this case, can tells us more about how much a buyer is willing to spend in a new vehicle than it is actually intended to operate a more ergonomic or easy to drive car.

A more simplified model is obtained after elimination of all the non-significant factors, in order to reduce discrepancy. This model again demonstrates the significant relationship between access to financial incentives and interest in plug-in hybrid vehicles, as well as the larger size of the currently driven vehicle also having a positive effect on interest. This model exhibits acceptable adjustment values, reinforcing the idea that, of a set of factors, presented most by Ritsuko & Sevastyanova (2011) with a plug-in hybrid buyers sample, only these two are in fact impacting the interest of the generality of people. The follow-up tests also allow us to conclude that larger households request, on average, a superior amount of incentive to adopt a plug-in hybrid vehicle. This confirmatory

analysis does not allow to corroborate all the factors that the previous exploratory analysis have pointed out as explanatory of the interest for plug-in hybrid vehicles, nor does it allow to confirm that the factors that took the buyers of plug-in hybrid vehicle to obtain these vehicles are determinant for most people`s options.

This study yields tax policy contributions by confirming the government`s ability to influence drivers' choices. Access to financial incentives is statistically significant in all three models and in almost all sampled divisions, although the amount requested for the purchase of a plug-in hybrid vehicle, in average for majority of drivers, is much higher than what is actually granted. This shows that drivers that currently do not hold a hybrid or electric vehicle and appreciate the incentives introduced by the green taxation reform, although it does not grant an amount capable of triggering a large-scale effect.

Consequently, the green tax reform in Portugal may not have the desired effect. Therefore, incentives provided should lower much more the gap between plug-in hybrids and ordinary vehicles purchasing prices.

5.1.1 Study Limitations

The impossibility of studying the business model due to the small size of sample is a limitation. Thus, it was not possible to analyze the incentive provided by the autonomous taxation feebate, as well as the relationship between the factors considered in the model with a business sample. This leaves aside a considerable number of users, but does not invalidate the conclusions of the presented models.

5.1.2 Future Research

The models presented in this study were constructed based on previous literary research and exploratory analyzes that support their factor structures. However, several of the factors proved to be incapable of explaining the interest in plug-in hybrids. We have noticed that the financial incentives and size of driver's vehicle positively influence

the interest for plug-in hybrids, but there is room to explore if other factors can influence this interest.

The presented study is done around plug-in hybrid vehicles, but these are not the only ones on the heels of green tax reform. Therefore, it would be interesting to explore the model developed in this study to test the effect of green taxation in the interest for electric vehicles, or for conventional hybrids, even though these last´s do not enjoy access to feebates, which offer a much higher discount. The models can also be used with a plug-in hybrid owners sample, to clearly understand if the Portuguese green tax system influenced their option.

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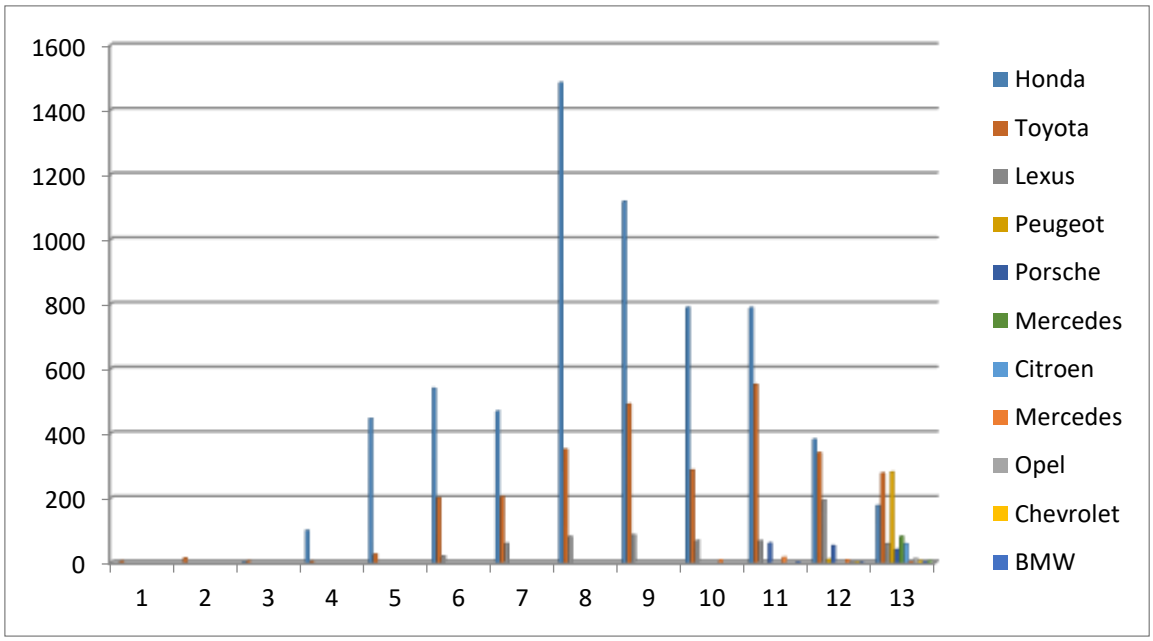
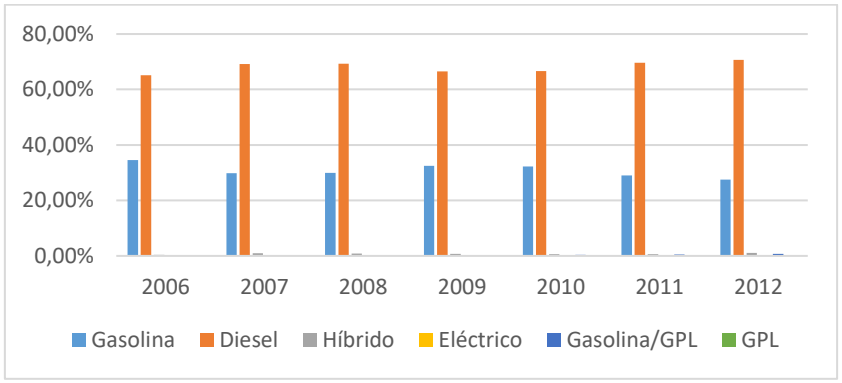
7 Attachments

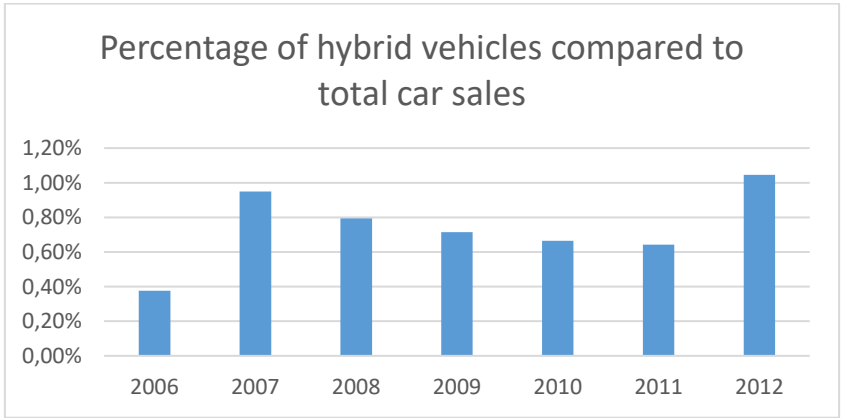
Attachment A- Sales of hybrid vehicles in Portugal (ACAP, 2013)



Attachment B - Percentage of hybrid in all car sales in Portugal (ACAP, 2013)



Attachment C - Percentage of hybrid in all car sales in Portugal II (ACAP, 2013)



Attachment D - Modification índices for business base model

Cov	M.I.
e33<-->e34	20,235
e32<-->e34	11,768

Attachment E - Model fit indicators for business model

Model Fit indicators	CMIN/DF	RMSEA	GFI	AGFI	RMR
Base model values	2,211	0,204	0,468	0,371	0,200
Modified model values	2,106	0,195	0,488	0,392	0,191
Reference values	<3	<0,08	>0,9	>0,9	<0,08

Attachment F - Factors to questions: business sample

Factors	Description	Questions	Factors	Description	Questions
E	Environmental awareness	4 5	**VS**	Vehicle size	23
OP	Independence fro oil producers	6 7	**R**	Whether or not you reside in a large center (Lisbon or Porto)	24
I	Image	8 9	**INS**	Income Scale	21
T	Tecnology	10 11	**HS**	Household size	20
F	Access to financial incentives	13 14	**EDUC**	Education level	22

Attachment G - Estimates of modified model

			Estimate	S.E.	C.R.	P
INT	<---	F	-1,194	0,457	-2,611	0,009
INT	<---	P	0,546	0,417	1,31	0,19
INT	<---	A	-0,314	0,163	-1,929	0,054
INT	<---	I	0,268	0,095	2,836	0,005
INT	<---	R	0,507	0,201	2,523	0,012
INT	<---	FOR	0,203	0,097	2,081	0,037
INT	<---	RN	-0,112	0,089	-1,259	0,208
INT	<---	AF	-0,129	0,074	-1,753	0,08
INT	<---	CD	-0,713	0,185	-3,861	***

Attachment H - Robustness tests for business sample

Division criteria	Tests		P-value
	Kruskal-Wallis	Mann-Whitney	
Household size	x		0,162
Vehicle size		x	0,579
Education level	x		0,872
Net monthly income	x		0,189
Place of residence		x	0,125

Attachment I - Questionnaire

The questionnaire was carried out in Portuguese, the following is a translated version:

Hybrid vehicles are vehicles that use a normal engine, working on diesel or gasoline, and an electric motor in movement. One segment of hybrid vehicles are hybrid plug-in vehicles. While conventional hybrids charge the electric motor battery while driving, the plug-in hybrids can charge their batteries directly into the electric current.
This questionnaire was made for a Final Thesis of the MSc in Accounting, Taxation and Business Finance, at ISEG.
If you would like additional information undergoes this questionnaire, please contact me by email: hugopadua14@gmail.com

Initial Questions

1) Hybrid vehicles began to be sold in Portugal in 2000. In your opinion, currently, the purchase of plug-in hybrid vehicle is more appealing?

◯ No opinion ◯ Less appealing ◯ Indifferent ◯ More appealing ◯ Very more appealing

2) The last time you searched a new car for yourself, did you consider buying a hybrid plug-in?

◯ I did not buy a car recently ◯ I did not consider ◯ I considered a little ◯ I considered ◯ I considered a lot

3) The ownership of your vehicle belongs to?

◯ I drive a vehicle with individual ownership ◯ I drive a business vehicle

Questions for Individual User

4) Do you agree that driving a plug-in hybrid helps solve the following environmental problems?:

	No opinion	Totally disagree	Disagree	Agree	Totally agree
Reduces the effects of climate change	◯	◯	◯	◯	◯
Preserves the environment	◯	◯	◯	◯	◯
Reduces pollution levels	◯	◯	◯	◯	◯
Reduces natural resources consumption	◯	◯	◯	◯	◯
Improves energy efficiency	◯	◯	◯	◯	◯

5) Do you daily recycle?

◯ I do not recycle ◯ Paper/Paperboard ◯ Plastic Products ◯ Glass ◯ Metals
◯ Mercury lamps ◯ Batteries

6) Do you agree with the following statements?:

	No opinion	Totally disagree	Disagree	Agree	Totally agree
Driving a plug-in hybrid contributes to our independence from oil producers	◯	◯	◯	◯	◯
Driving a plug-in hybrid leaves you less exposed to fluctuations in fuel prices	◯	◯	◯	◯	◯

7) In your opinion, reducing dependence on oil or fuel consumption?

◯ Doesn't matter ◯ Petty matters ◯ Is important ◯ Is quite important ◯ Is very important

8) Do you agree that driving a plug-in hybrid means?

	No opinion	Totally disagree	Disagree	Agree	Totally agree
You are doing what is right	◯	◯	◯	◯	◯
It marks a trend for environmentally					

friendly technologies	◯	◯	◯	◯	◯
Is regardful to others	◯	◯	◯	◯	◯
Shares society common values	◯	◯	◯	◯	◯
Is socially responsible	◯	◯	◯	◯	◯

9) Do you believe that in your social environment, concern for the environment is appreciated?

◯ Nothing appreciated ◯ Little appreciated ◯ Appreciated ◯ Quite appreciated ◯ Very appreciated

10) Do you agree that a plug-in hybrid represents a new / modern technology?

◯ Yes ◯ No

11) You acquire or seek to know more about new technologies?

◯ I'm not interested ◯ I have little interest ◯ I am very interested

12) Do you agree that driving a plug-in hybrid gives you access to the following benefits ?:

	No opinion	Totally disagree	Disagree	Agree	Totally agree
Lower fuel spending	◯	◯	◯	◯	◯
Free parking access	◯	◯	◯	◯	◯
Access to a discount, through motor tax for low CO2 emissions	◯	◯	◯	◯	◯
Access to an intermediate rate where plug-in hybrids only pay 25% of the amount applied to other vehicles in motor tax	◯	◯	◯	◯	◯
Higher car scrappage incentive	◯	◯	◯	◯	◯

13) How do you evaluate the following incentives for the purchase of plug-in hybrids?:

	No opinion	Doesn't matter	Petty matters	Important	Very important
Car scrappage scheme	◯	◯	◯	◯	◯
Pay 25% of the total amount of motor tax	◯	◯	◯	◯	◯
Discounts on purchase for low CO2 emissions	◯	◯	◯	◯	◯

14) Which of the following do you consider important?:

	No opinion	Doesn't matter	Petty matters	Important	Very important
Assignment of a fixed incentive (not variable by vehicle characteristics) for the purchase of a plug-in hybrid	◯	◯	◯	◯	◯
Variable incentive allocation (by vehicle characteristics) for the purchase of a plug-in hybrid	◯	◯	◯	◯	◯
Free parking	◯	◯	◯	◯	◯
Only green vehicles can circulate on some streets	◯	◯	◯	◯	◯
Non-taxation by cylinder capacity and only by CO2 emissions	◯	◯	◯	◯	◯
Assign an annual premium to anyone with a plug-in hybrid, rather than a discount on the purchase	◯	◯	◯	◯	◯

15) In your opinion, when compared to other vehicles, is plug-in hybrid usage (fuel expenses, maintenance, among others) more expensive?

◯ No opinion ◯ Totaly disagree ◯ Disagree ◯ Agree ◯ Totally agree

16) A Toyota Auris costs about € 25,000, while the Toyota Prius Plug-in costs around € 35,000, with features similar to the Auris. The difference in price is € 10,000. What amount of premium it takes for you to be interested in purchasing the Prius Plug-in instead of the Auris?_____

Questions for business users

4) Do you agree that driving a plug-in hybrid helps solve the following environmental problems ?:

	No opinion	Totally disagree	Disagree	Agree	Totally agree
Reduces the effects of climate change	◯	◯	◯	◯	◯
Preserves the environment	◯	◯	◯	◯	◯

Reduces pollution levels	◯	◯	◯	◯	◯
Reduces natural resources consumption	◯	◯	◯	◯	◯
Improves energy efficiency	◯	◯	◯	◯	◯

5) In the normal course of your business, is your company environmentally responsible?

◯ Yes ◯ No

6) Do you agree with the following statements?:

	No opinion	Totally disagree	Disagree	Agree	Totally agree
Driving a plug-in hybrid contributes to our independence from oil producers	◯	◯	◯	◯	◯
Driving a plug-in hybrid leaves you less exposed to fluctuations in fuel prices	◯	◯	◯	◯	◯

7) In your company, reduce dependence on oil or fuel consumption is?

◯ Doesn't matter ◯ Petty matters ◯ Important ◯ Quite important ◯ Very important

8) Do you agree that driving a plug-in hybrid means?

	No opinion	Totally disagree	Disagree	Agree	Totally agree
You are doing what is right	◯	◯	◯	◯	◯
It marks a trend for environmentally friendly technologies	◯	◯	◯	◯	◯
Is regardful to others	◯	◯	◯	◯	◯
Shares society common values	◯	◯	◯	◯	◯
Is socially responsible	◯	◯	◯	◯	◯

9) The stakeholders of your company (customers, suppliers, among others) appreciate or require more sustainable practices

◯ Nothing appreciated ◯ Little appreciated ◯ Appreciated ◯ Quite appreciated ◯ Very appreciated

10) Do you agree that a plug-in hybrid represents a new / modern technology?

◯ Yes ◯ No

11) Does your company invest in new technologies?

◯ No ◯ A little ◯ I am very interested

12) You celebrated a contract with your company to attach the use of the vehicle to you, earning an extra income for related expenses for which you pay IRS?:

◯ Yes ◯ No

13) Do you agree that driving a plug-in hybrid gives you access to the following benefits ?:

	No opinion	Totally disagree	Disagree	Agree	Totally agree
Lower fuel spending	◯	◯	◯	◯	◯
Free parking access	◯	◯	◯	◯	◯
Access to a discount, through motor tax for low CO2 emissions	◯	◯	◯	◯	◯
Access to an intermediate rate where plug-in hybrids only pay 25% of the amount applied to other vehicles in motor tax	◯	◯	◯	◯	◯
Higher car scrappage incentive	◯	◯	◯	◯	◯
Access to a discount, in the autonomous tax rates, for use of the vehicle	◯	◯	◯	◯	◯
Possibility of depreciating the vehicle up to a limit higher than that of other vehicles	◯	◯	◯	◯	◯

14) How do you evaluate the following incentives for the purchase of plug-in hybrids ?:

	No opinion	Doesn't matter	Petty matters	Important	Very important
Car scrappage scheme	◯	◯	◯	◯	◯
Pay 25% of the total amount of motor tax	◯	◯	◯	◯	◯
Discounts on purchase for low CO2 emissions	◯	◯	◯	◯	◯
Discount on autonomous taxation (reduced rates)	◯	◯	◯	◯	◯
Increase in the depreciation limit	◯	◯	◯	◯	◯

15) Which of the following do you consider important ?:

	No opinion	Doesn't matter	Petty matters	Important	Very important
Assignment of a fixed incentive (not variable by vehicle characteristics) for the purchase of a plug-in hybrid	◯	◯	◯	◯	◯
Variable incentive allocation (by vehicle characteristics) for the purchase of a plug-in hybrid	◯	◯	◯	◯	◯
Free parking	◯	◯	◯	◯	◯
Only green vehicles can circulate on some streets	◯	◯	◯	◯	◯
Non-taxation by cylinder capacity and only by CO2 emissions	◯	◯	◯	◯	◯
Assign an annual premium to anyone with a plug-in hybrid, rather than a discount on the purchase	◯	◯	◯	◯	◯
Non-taxation, in the case of autonomous taxation, of depreciation not accepted fiscally	◯	◯	◯	◯	◯
No depreciation limit for hybrid plug-in vehicles	◯	◯	◯	◯	◯

16) In your opinion, when compared to other vehicles, is plug-in hybrid usage (fuel expenses, maintenance, among others) more expensive?

◯ No opinion ◯ Totaly disagree ◯ Disagree ◯ Agree ◯ Totally agree

17) A Toyota Auris costs about € 25,000, while the Toyota Prius Plug-in costs around € 35,000, with features similar to the Auris. The difference in price is € 10,000. What amount of premium it takes for you to be interested in purchasing the Prius Plug-in instead of the Auris?_____

Final Questions

18) What is your gender?

◯ Male ◯ Female

19) How old are you?

_____

20) What is your household size?

_____

21) What is your net monthly household income?

◯ 0-1000€ ◯ 1000-2000€ ◯ 2000-3000€ ◯ 3000-4000€ ◯ >4000€

22) What is your school education level?

◯ Basic education ◯ High school ◯ Graduation ◯ Masters ◯ PhD

23) Which vehicle do you currently drive?

Brand: _____

Model: _____

24) In what district you live in?

◯ Açores ◯ Aveiro ◯ Beja ◯ Braga ◯ Bragança
◯ Castelo Branco ◯ Coimbra ◯ Évora ◯ Faro ◯ Guarda
◯ Leiria ◯ Lisboa ◯ Madeira ◯ Portalegre ◯ Porto
◯ Santarém ◯ Setúbal ◯ Viana do Castelo ◯ Vila Real ◯ Viseu