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Willingness to pay for electric vehicles in island regions: The case of Tenerife (Canary Islands)

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ABSTRACT

Electric vehicles (EVs) could be a solution to reduce final energy consumption and carbon emissions in the road transport sector. Moreover, the mobility characteristics of drivers (i.e., their average driving distance) fit better with current EV technical features on a small island than in the mainland. This paper analyzes willingness-to-change (WTC) and willingness-to-pay (WTP) for an EV in Tenerife (Canary Islands), both of which are key factors for understanding potential for EV penetration. WTC and WTP in Tenerife island are estimated based on data collected through a face-to-face survey-based contingent valuation approach. We go on to assess the impact of a set of explanatory variables on both WTC and WTP, in order to characterize the representative profile of a potential EV buyer. Informing on the basic properties of an EV and environmental concerns are found to be key factors for WTC, while income level, mobility patterns, environmental concerns and attitude-to-tech of potential buyers are found to be important factors for WTP.

1. Introduction

The 2015 Climate Change Conference held in Paris brought together leaders, experts and scientists from around the world to discuss the challenges and new policies for mitigating climate change [1]. In response, the EU established the Winter Package promoting new measures to boost the provision of renewable energies and create new energy markets in the EU [2]. The task is even more challenging for Europe's more isolated regions, like the Canary Islands (Spain), mainly due to their specific geographic conditions. The Canary Islands archipelago is almost totally dependent on fossil fuels as a primary energy source, which accounts for 98.9% of energy used whereas only 8.4% of electricity generated in the islands comes from renewables [3–5]. Marrero and Ramos-Real [6] highlight chronic inefficiency in the island's electricity sector, overruns, high fuel price volatility risk, and the high rate of CO_2 in the final product. However, introducing renewable sources such as wind or photovoltaics is no easy task in small and isolated islands, mainly due to the intermittency and small size of the power systems [7]. To overcome this problem, energy storage could be a solution, as it adds stability to the electric power systems [8–10], which may help increase share of renewables.

Electric vehicles (EVs) could be part of the solution for isolated systems, as they can be used not only as energy storage systems but also as demand-side response devices [8,11]. Moreover, EVs provide other benefits to electric power systems, including voltage and frequency regulation, backup for renewable intermittency, and peak shaving [12–14]. However, in order to benefit from these advantages, it is first necessary to introduce specific regulatory reforms to overcome certain market barriers [15]. Various strategies based on sharing EV cars in cities have been tested around the world [16,17], and similar initiatives could be applied in the Canary Islands, where traffic congestion is a serious issue [18].[1] According to [10], the introduction of 50,000 EVs as distributed energy storage in the island of Tenerife (Canary Islands) could increase the share of renewables by up to 30% and reduce CO_2

Abbreviations: CV, Contingent valuation; EVs, electric vehicles; ECI, environmental concern index; ICT, information and communication technologies; ICTI, information and communication technologies index; WTC, willingness-to-change; WTP, willingness-to-pay

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[1] The Canary Islands counted 631 vehicles per thousand inhabitants in 2015, a rate that is higher than the Spanish average (481) and the EU-28 average (497).

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emissions by 27%. However, despite both these potential benefits and Spanish government support through financial incentives, EV sales in the islands remain sluggish compared to the mainland [19,20].[2]

In addition to the benefits mentioned above, the Canary Islands present a set of characteristics that make the introduction of EV even more attractive. The small size of the territory dictates driver mobility routines, as the short average travel distance reduces the effects of range anxiety. There is therefore a need to promote new business models based on 'e-mobility' [21–23]. Studies assessing the characteristics of early adopters [24,25] have found that identifying these customers and their characteristics facilitates the promotion of EVs in the market. Furthermore, policymakers and private companies could use experiences with EV and barriers to EV adoption as a start point to design strategies geared to wider adoption of this disruptive technology.

Two concepts are useful for analyzing the profile of a potential EV buyer. First is the willingness to change (WTC) to an EV, and second is the willingness to pay (WTP) for an EV. From an empirical point of view, an early adopter can be defined as an individual who is willing to change from a conventional car and also more willing to pay for an EV [26]. Contingent valuation (CV) is a widely used method for tackling this issue. The CV method is to directly interview consumers, creating a realistic (but hypothetical) market scenario that starts by describing a good or service and ends by getting respondents to directly state their willingness to acquire or pay for it [27,28].

The aim of this paper is to analyze the EV market in the Canary Islands and the characteristics of EV early adopters. The paper performs a two-step evaluation of WTC for EVs in order to evaluate the impact before and after providing potential buyers general information on EVs [29]. WTP for an EV is also calculated in order to quantify potential EV sales. The data used comes from an original survey on representative sample of 250 private car drivers in Tenerife. Binary logistic (*logit* and *probit*) and continuous (*tobit*) regression approaches are used to analyze the impacts of a set of explanatory variables on WTC and WTP for EVs. We explore the inclusion of two relevant issues measured through synthetic indexes, i.e. *environmental concerns* and use of *Information and Communication Technologies* (ICT), that could be decisive in shaping individual attitude to EVs.

This work brings an important empirical contribution to the literature by identifying the potential reservoir of EV early adopters within an isolated island region. The results reveal that mobility routines affect early-adopter decisions in island conditions due to the kilometers covered and range required by car drivers. We find that WTP correlates positively with income, age and education level, and that the early adopters tend to be ICT-friendly and environmentally conscious.

Section 2 presents the empirical application (the CV experiment) and describes the survey structure and the sample. Section 3 presents the descriptive results of the survey and an estimation of potential EV sales. Section 4 details and discusses the outcomes of the logistic and continuous regressions. Finally, Section 5 concludes.

2. Contingent valuation experiment

Carson [27] asserts contingent valuation (CV) as a widely used technique for the measurement of WTP and the valuation of public goods and services. The method consists in using interviews to create a realistic (although hypothetical) market scenario, that starts by describing the good or service and ends by getting respondent to directly state their WTP (and also WTC) for it. This CV methodology has been used for market valuation of non-market and new-to-market products and/or services [30]. Governmental agencies and international organizations have applied this same technique to assess the potential market [28] and WTP for energy [31–33], pollution [34] and transport [35] solutions.

Focusing on EV studies, Thiel et al. [29] led a CV experiment to determine intention to buy an EV in a set of European countries and found that in Spain, 50% of car drivers would be willing to buy an EV, just behind Italy at 54% but well ahead of France at 30%, Germany at 31%, and the UK at 27%. Other studies assessing WTP for EVs highlight the value of improving knowledge on EVs and find that the most important common features that explain EV purchases are levels of emissions, individual incomes, environmental awareness, and educational attainment [36,37].

Here we use a CV experiment to assess two important factors: i) WTC from a conventional car to an EV, and ii) WTP for an EV. WTC is assessed using a dichotomous Yes/No question. The concept is defined by the respondent's readiness to pay more for an EV instead of their preferred conventional vehicle. This definition does not mean the consumer is immediately going to buy an EV, but that they are a candidate buyer of this new technology. WTP is assessed using an open-ended question and the payment card elicitation. First, we ask for the WTP for a new conventional car (open-ended format). If the respondent is willing to change to an EV, we ask how much more they would be willing to pay for it (open-ended format). If the respondent is willing to pay less for an EV, we then ask for the discount rate (via payment card format) on the amount of money previously stated in the WTP for a new conventional car.

Oerlemans et al. [38] analyze different CV formats and find that the open-ended question is easy and convenient for respondents to answer with complete freedom. The payment card format then offers a simple ranged response and greater efficiency than the dichotomous choice. The structure of our CV experiment is described below.

2.1. Survey structure

To develop the CV survey, we considered the use of an iterative face-to-face pilot questionnaire designed by an expert focus group.[3] The questionnaire is described in full in Appendix A. Following Carson [27], the CV survey design is structured as follows: a) presentation of the purpose of the survey; b) detailed description of the good to be valued and its conditions of purchase; c) elicitation section to ask about WTC and WTP; d) socio-demographic characteristics of the respondents. Building on this structure, we propose an original CV survey with five main steps. First, respondents are briefed on the survey (step 1). Next, respondents are asked about their mobility characteristics (step 2). In this step, they answer with their average distance travelled per day, distinguishing between weekdays and weekends, after which we ask them about the minimum range that would prompt them to buy a vehicle [39].

In step 3, we obtain the WTC and WTP for an EV (Fig. 1). First, we give an open-ended question on WTP for a new conventional vehicle (question 4 in the questionnaire). Then we describe hypothetical scenarios on EV infrastructure location on the island and on purchasing conditions in order to start the CV experiment. Respondents are then given two assumptions: i) there is a charging infrastructure distributed around the island and the user has a charging station at home; ii) the EV

[2] According to the *Dirección General de Tráfico* [Spanish 'Directorate-General of Traffic'], a total of 127 EVs have been sold in the Canary Islands (0.21% of overall car sales), a share that is clearly lower than in the rest of Spain (0.27%) and far lower than in leading countries such as the UK (1.1%), the Netherlands (3%) and Norway (22.9%).

[3] The survey design process was conducted by an expert focus group counting academics, researchers and industry experts. Two different rounds of 10 in-depth interviews using a preliminary questionnaire were delivered to an initial group of respondents in order to check the internal validity of the survey. The suggestions provided by these respondents and the expertise of the focus-group members then helped design the final questionnaire.