



**Abstract ampliado**

## RESUMEN AMPLIADO

**Título:** Environmental awareness and willingness to pay for offsetting CO2 emissions in urban areas through the introduction of hybrid buses

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**Resumen:** (*mínimo 1500 palabras*)

In a context of growing environmental awareness, strengthened by the Paris Agreement on climate change, the introduction of alternatively-fuelled vehicles for public transportation in urban areas densely populated is considered by some to be desirable for the achievement of long-term climate policy objectives aimed at reducing the problem of global warming. In fact, the European Clean Bus Deployment Initiative, through the combined efforts of cities, regions, transport authorities and manufacturers, seeks the promotion of low-and-zero-emission mobility in the European cities and regions. Although alternative technologies are crucial for reducing the emissions associated with urban transport, oil-based mobility still accounts for the largest share of the market in the European Union and elsewhere. In fact, alternative fuel vehicles make up 2% of the total bus fleet. Hence the incremental implementation of hybrid electric technology, that provides an average 21% reduction in greenhouse gases emissions and 26% savings in fuel consumption, can be considered a first step, although not definitive, towards a low-carbon mobility.

Currently in Valencia (Spain) 42 hybrid buses and 2 electric buses are in use and it is expected an increase in the future despite their higher acquisition cost. These alternative energy buses account for less than 9% of the current fleet. This paper uses the Contingent Valuation method in order to estimate how much college students in the city of Valencia are willing to pay for an increase in their well-being resulting from air pollution reductions (CO2) associated with a scenario of large-scale introduction of hybrid buses in the urban public transport network. The Contingent Valuation method is a survey-based approach used to assign a value on public goods that are not usually traded in the market and hence their value is unknown. Thus, through the use of a questionnaire, a hypothetical valuation framework is constructed in which respondents are asked about their willingness to pay for the hypothetical provision of a public good (in this case, hybrid buses) that increases their well-being or less often about their willingness to accept in compensation for a decrease in the amount of the public good offered. With this purpose, 427 college students of the different campus and faculties of the University of Valencia were surveyed. Results show that 67% of the respondents are



willing to pay extra for the adoption of this electric hybrid technology, being the mean willingness to pay € 0.33 that would imply a 22% increase in bus fares. This increase is justified considering that hybrid electric buses are on average 46% more expensive than their diesel counterparts, although their operational costs (maintenance and running cost per kilometre) are lower.

Now considering the fact that unobserved heterogeneity abounds in contingent valuation studies, a Latent Class Analysis (LCA) was carried out to address the issue of heterogeneity. LCA is a statistical method that endogenously creates different latent classes (or clusters) composed of relatively homogeneous responses. These classes are called latent because they are not directly observed. Each class is a weighted average of respondents and each respondent has a positive probability of membership in each class. Overall, the results indicate that there is large diversity in the preferences towards the use of hybrid buses. In particular, on the basis of twelve different statements that measure the environmental concern of the individuals interviewed using a 5-point Likert scale, we conducted LCA considering that the number of classes ranged between  $C=2$  to  $C=5$ . Then, based on the Bayesian Information Criterion and the Akaike Information Criterion, the best model is the one that minimises the information criteria, i.e. a 3-class model in this particular case. The average membership probability of class 1, class 2 and class 3 were 50%, 32% and 18%, respectively. The estimated class-conditional outcome probabilities were then used to characterize the three different classes. Hence the probabilities values, and its plot, of each response to the twelve environmental indicators were used to describe the three classes.

Class 1 was named “highly environmental concerned” class. About 89% of respondents in this class when asked about the “importance given to the protection and preservation of the environment”, answered “very important”. In the same way, around 85% of them “strongly agree” with the statement “I am afraid when I think about environmental conditions for future generations”. About 81% of the respondents “strongly agree” with the statement “climate change is already a reality as average temperatures have increased and climate catastrophes are becoming more common” and also 93% of them “strongly agree” with the statement “If we continue our current style of living, we are approaching an environmental catastrophe”. Another interesting statement was “In my opinion, environmental problems are greatly exaggerated by proponents of the environmental movement”. In this case, 72% of respondents “strongly disagree”.

Class 2 was named “Medium environmental concerned”. In this class, 57% of respondents stated that for them “the protection and preservation of the environment” was “very important”, while for the rest of statements the respective percentages were 44%, 49%, 49%, and 30%, noticeable lower than those from the previous class.

Finally, class 3 was named as “low environmental concerned”. In this class, only 15% of respondents stated that “the protection and preservation of the environment” was “very important” for them. The percentages for the rest of statements were the lowest ones: 8%, 26%, 11% and 13%, respectively.

In the same way, in order to refine the results, an extension of the latent class analysis model was used to consider the effect of some covariates on the probability of membership to each class. In particular, “membership in an environmental organization” had a very significant and positive on class 1 (highly environmental concerned) while for class 3 (low environmental concerned) was also significant but with negative coefficient. The fact of “being enrolled in a science degree” was significant, especially for class 1 and 3, although in the first case the coefficient was positive and, in the second, negative. The fact of “being willing to pay for the



introduction of hybrid buses in the public transport network” was again especially significant for classes 1 and 2. The respondent’s “age” was significant in explaining class-2 membership while “gender” was significant for classes 1 and 3. Finally, “family income”, “household size” and “membership in a citizen action platform” were no significant in explaining class membership.

When asked respondents about their perception of the air quality in Valencia, for the whole sample, 38% of them sated “very bad” or “bad”, while for the three different classes these same percentages were 45%, 36% and 22%, respectively. So individuals belonging to class 1 (highly environmental concerned) seem to have a worse image of air quality in Valencia and supposedly a higher willingness to pay for improving it.

Regression analysis was used to estimate bid functions for each one of the three classes identified, thus addressing the issue of heterogeneity while validating the results from a theoretical point of view. Considering the censored nature of the dependent variable (stated willingness to pay values are censored at zero), a Tobit regression approach was followed. Again, the results of the three models show that there is heterogeneity amongst the respondents regarding their willingness to pay for offsetting CO<sub>2</sub> emissions through the introduction of alternative energy buses for urban transport. As expected, the percentage of respondents willing to pay extra was different for each class: 77% for class 1, 62% for class 2 and 47% for class 3. Hence the highest mean willingness to pay obtained was for class 1 (€ 0.40), while for classes 2 and 3 this same value was € 0.31 and € 0.19, respectively. The corresponding hypothetical increase in bus fares would be for each class, 27%, 21% and 13%, respectively. So respondents that have a worse image of air quality in Valencia (class 1), have a higher willingness to pay.

No previous study in Spain has attempted to analyse public preferences for hybrid buses using the Contingent Valuation method. Therefore, the estimated values of this research may be of major interest for decision makers since they provide guidance on the potential increase in bus fares that a portion of the population of Valencia might be willing to pay in order to improve the air quality. Nevertheless, we cannot ignore the distributional effects of this policy since the rest of the citizens that are not regular users of public transport and consequently do not pay for it, could also be benefited from this policy given the positive externality associated with the introduction of this alternative technology.

Finally, it may be noted that this research is subject to some limitations as it is the fact that the sample was restricted to one part of the users of public transport: college students. So we have to be very cautious in extrapolating these results to the whole population if our intention is to provide an aggregate estimation of the social benefits associated with the large-scale introduction of hybrid buses in Valencia. In any case and despite its limitations, we hope that this study can be helpful in paving the way for future research in this area.

**Palabras Clave:** *Contingent valuation; hybrid buses; willingness to pay; latent class analysis; heterogeneity.*

**Clasificación JEL:** Q51; Q54; L91.