Italian youngsters' perceptions of alternative fuel vehicles: a fuzzy-set approach

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Abstract

This study analyzes the attitude of Italian youngsters toward the adoption of alternative fuel vehicles (AFVs), using the fuzzy-set qualitative comparative analysis. An internet and face-to face questionnaire survey collects the intensity of knowledge, perceptions, and attitudes toward alternative fuel vehicles of Italian university students. A survey among youngster allows understanding the view of the future generation regarding alternative fuel vehicles technologies. The findings from the survey (n = 330) indicate the relevant determinants that spur the purchase of alternative fuel vehicles, the type of technology preferred among such vehicles, the specific related environmental benefits and the related barriers that youngsters perceive. Consumers' acceptance is crucial in the development of AFVs. This article also includes practical implications for both policymakers and manufacturers.

Keywords: Alternative fuel vehicles; fsQCA; theory of planned behavior; consumer attitude

1. Introduction

The transport sector is currently responsible for 23% of global energy-related carbon dioxide (CO_2) emissions (International Energy Agency, 2015). Environmental policies seek to reduce CO_2 emissions in vehicles so as to become a low-carbon society. This article focuses on alternative fuel vehicles (AFVs), including battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs).

BEVs rely entirely on a battery and electric drive train. They seem to be an ideal solution to contribute to energy-dependency reduction and climate-change mitigation, because they do not use petroleum fuel consumption and have zero local emissions (Perujo & Ciuffo, 2010). HEVs have two sources of energy and/or two or more sources of power in the vehicle. They save energy and reduce emissions by combining an electric motor and an internal combustion engine (Amjad et al., 2010). PHEVs rely mostly on batteries that recharge by plugging into the power system, thus representing a significant advancement of the HEVs (Torres et al.2014).

Among the different and relevant benefit-types of the adoption of AFVs, one is the reduction of emissions. However, although AFVs have favorable objective characteristics in terms of environmental friendliness, obstacles exist to the wide adoption of AFVs such as or reliability, mileage autonomy, storage, and complexity of the recharging (Egbue & Long, 2012; Krause et al., 2015).

The success of innovations depends on the consensus of consumers to new products and new technologies; consumers' needs and preferences are important. Consumers' acceptance is crucial in the development of AFVs (Ozaki & Sevastyanova, 2011). Automobile manufacturers are facing a period of rapid change because AFVs' technologies development is occurring at a rapid pace. Most of the existing literature analyzes consumers' preferences for AFVs using data from stated choice experiments (Al-Alawi & Bradley, 2013;

Sang & Bekhet, 2015). However, very few studies shed light on the interrelation between AFVs deployment and youngsters' attitude, thus exploring consumers' preference depending on age (Shin et al., 2015). The investigation of young people's preferences is important for two main reasons. First, green consumption relates to youth culture for historical reasons (Autio & Heinonen, 2004). Second, currently, a strong public awareness of environmental issues exists; thus, young consumers are more likely to be sensitive to these issues and to perform greener consumer behaviors (Diamantopoulos et al., 2003; Tseng & Hung, 2013).

This study intends to fill this gap by exploring the attitude of Italian youngsters toward the adoption of AFVs, using the fuzzy-set qualitative comparative analysis (fsQCA). In particular, the objective of this study is twofold: To analyze the decisively positive attitude toward AFV and decisively refusal attitude toward AFVs.

To this end, the study passes a questionnaire among a sample of 330 Italian university students according to the theory of planned behaviour (TPB). The TPB (Ajzen, 1991; Armitage & Conner, 2001) is a prediction model of purchasing behaviour building on behaviour norms, subjective norms, and perceived control over the behaviour (Davies et al., 2002; De Cannière et al., 2009; Ouelette & Wood, 1998). The questionnaire survey takes into account Italian university students willingness to pay (WTP) and explores their knowledge, perceptions, and attitudes related to AFVs. Hence, this study highlights benefits and barriers that youngsters face if trying to make green choices such as the purchase of AFVs.

Section 2 presents the literature review. Section 3 describes the material and methods. Section 4 presents the results. Finally, Section 5 provides discussion and conclusions.

2. Literature review

The recent literature investigates consumers' preferences regarding AFVs, assessing the effect of AFVs' features. For example, environmental concerns play a key role in spurring

green purchasing behavior (Hartmann & Apaolaza-Ibáñez, 2012). However, AFVs are not yet competitive in comparison to conventional fuel vehicles. Because of the early stage of development of the AFVs technology, some studies examine how much car buyers care about the environment and consequently their car purchase decisions. Some literature investigates to what extent age, education, gender, and income influence consumers' AFVs purchase decision. Results are ambiguous. On the one hand, Hersch and Viscusi (2006) find out that gender is not important in AFV's purchase decision. Older people have a significant lower attitude towards AFVs, meaning that younger people have more concerns about environmental problems than older ones. On the other hand, Torgler and García-Valiñas (2007) show that women are more likely to purchase AFVs than men are due to women's stronger environmental concerns. Regarding educational issues, higher levels of education have a significant influence on the willingness to contribute to the improvement of the environment (Israel & Levinson, 2004).

Most of the literature focuses on barriers to the widespread adoption of AFVs, the most important being technical, economic, and infrastructural barriers (Ahn et al.2008; Egbue & Long, 2012; Ramirez, 2013; Rezvani et al., 2015). Technical barriers mainly associate with battery technology. For instance, the current battery technology of AFVs necessitates frequent recharging and costly replacement, bringing the AFVs to be less attractive in the market (Ito et al., 2013). Economic and infrastructural barriers mainly associate with cost of batteries and the logistics of recharging. Attributes such as refueling, cost of batteries, and fuel availability are the focus of this study. Purchase price and driving range are important attribute to analyze the demand for AFVs. The limited driving range for AFVs should substantially increase so that they can be competitive in the automobile market. Because of this fact, men are seemingly more reserved towards this technology than women are (Dagsvik et al., 2002). Achtnicht (2012) shows that, on average, CO2 emissions per kilometer is a

relevant attribute in car choices for German car buyers. The consideration of CO2 emissions varies heavily across the sample and the demand for AFVs increases with youth and education. However, not many studies exist that examine young people attitudes and perceptions toward AFVs, which is a crucial issue to the understanding of AFVs successful adoption. Kumar (2010) analyzes the marketing model to catch the young customers in automobile industry with a sample of students in India. The model, which comprises three phases— presentation, the factory visit, and the test drive—, has been capable of attracting young customers.

The deployment of the AFVs goes through cultural and political process. If companies and political authorities investigate preconceptions about what a car is, what problems affect AFVs technology, and which users are more likely to accept AFVs, AFVs could experience a rapid expansion in the near future (Gjøen & Hård, 2002).

This study contributes toward a better understanding of youngsters' buying behavior in the AFVs sector in Italy. Indeed, in Italy, as in many countries, the new educated younger generations are using more and more environmental-friendly goods. This study enriches the literature and provides useful information on consumer purchasing behavior in Italy to the business sector of AFVs, to identify marketing opportunities and to ensure greater deployment of AFVs.

3. Material and methods

3.1. Data

The study uses a questionnaire to investigate youngsters' attitudes toward AFVs .The study administered the questionnaire to a sample of 330 individuals in the months of May and June via online, using the University of Perugia intranet database, and via face-to-face interaction, mainly during class intervals in the hallways of the university campus.

The sample has a higher share of males (56%) than females (44%). The region of origin is 89% from Central Italy, which is an area with average income and social characteristics in Italy. The majority is between the age of 19-20 years (85%), and the remaining 15% is between 21 and 25. Fifty six percent of the family has an income below 30,000 euro (roughly the Italian average income), whereas 13% have an income between 30,000 and 40,000, and 31% above 40,000. Almost three quarters of the students live with their family, approximately 50% of the students use very frequently their own cars, and 16% usually walk to the university campus.

See Table 1 for the distribution of the main relevant questions relative to the respondents' attitudes toward AFVs. The rows of the first and third panel show the percentage of respondents according to a 5-point Likert scale ranging from 1 = *strongly disagree* (never) to 5 = *strongly agree* (always). The last column reports the average score of each attitude. For instance, 56% of the respondents use private car always. Consequently, the average attitude toward private car is 4.1, which means "almost always." The second panel reports the dichotomous distribution of the percentage of respondents who have actually experienced AFVs. The fourth panel reports the distribution of the respondents' main concerns about AFVs.

Table 1 here.

About half of respondents (56%) uses most frequently the private car as a means of transport and, on average, they make 15 kilometers per day. Seventy-five percent of the respondents have never tried AFVs, and the remaining has tried mainly HEVs (12%), BEVs (5%), and other non-conventional fuels. From an environmental point of view, the AFVs are definitively attractive for the respondents because they emit less carbon dioxide (40%) and they reduce of oil consumption (36%). In terms of AFVs performance and characteristics,

respondents consider the most attractive cost reduction in comparison to fuel (63%), low levels of noise emission (32%), and less maintenance than conventional vehicles (18%).

However, some concerns toward AFVs arise among the respondents, with particular reference to the driving range (33%), charging station infrastructure (25%) purchasing costs of AFVs and cost of batteries (18%), reliability (12%), safety (7%), charging time (2%), and less performance in comparison to conventional vehicles (1%).

3.2. Method

The study uses fsQCA to identify possible configurations of joint determinants of the outcome of interest (Fiss, 2011). According to a recent literature, fsQCA has some advantages over the usual regression analysis (Woodside, 2013) such as equifinality, multifinality, joint causality, and asymmetric causality (Basedau & Richter, 2014; Gonçalves et al., 2016; Rihoux & Ragin, 2009). The study uses the fsQCA 2.0 software (Ragin, 2008a). The study analyzes two opposite viewpoints: Decisively positive attitude toward AFV and decisively refusal attitude toward AFVs.

According to the fsQCA procedure, this study conducts the preliminary analysis of the necessary and sufficient conditions for the calibration process, following the calibration process used in Woodside (2013). The outcome is the positive/negative attitude toward AFV in the survey and the set of independent variables are the attributes previously described. The study calibrates the variables according to the three-level anchoring method, using the 5-point Likert scale: Full membership at the rating of 5; full non-membership at the rating of 1; cross-over at the rating of 3. The study uses the same method for continuous variables, using 5 quintiles cut-off points (e.g., the 5th quintile threshold defines the full membership, and so on).

The study uses fsQCA with the following variables: The outcome is the youngsters' interest in AFVs, named *att*. The variables are *age*, which is relevant to detect college students at different stages of their degree (in Italy, typically a university degree lasts 5 years); *car*, which represents the frequency of use of a car; *exp*, that is experience, which measures the intensity with which respondents have ever tried and appreciated AFVs; *redn*, that is household income, measured in 5 classes from 10,000 to over 40,000 €; *clim*, which measures the attractiveness of AFVs in terms of climate change mitigation; *know*, which measures the intensity with which respondents know, or are familiar with, the issue of environmental sustainability.

4. Results

Results show the relevant variables that spur the purchase of AFVs. In addition, results show the concerns about reliability of the battery and of the charging facilities, the interest for the type of technology preferred among BEVs, HEVs and PHEVs and the specific related environmental benefits perceived by consumers.

This study applies fsQCA to explore two models. The first shows which conditions lead youngsters to show a definite interest in AFV. The second shows the conditions that render youngsters attitude toward AFV definitely negative.

This study employs the standard method to construct the data matrix, to reduce the number of rows, and to analyze the truth table (Fiss et al., 2013; Jenson et al., 2016; Mas-Verdú et al., 2015). According to this method, the variables identified above are all almost necessary. Table 2 shows the resulting truth table, with consistency values generally above 0.80.

Table 2 here.

Table 3 shows the empirical results of the fsQCA analysis, reporting both the intermediate and parsimonious solutions for the outcome variable *att*, that is, showing the conditions for respondents' positive and negative attitudes towards AFVs. This study discusses the sufficient and core conditions.

Table 3 here.

The intermediate solutions appear to be informative for positive *att*, with a solution coverage of 0.89 and solution consistency of 0.75 (Ragin, 2008b). Notice that all four configurations reported here have a consistency values well above the threshold value of 0.80 indicated by Ragin (2008b). The negated outcome, *-att*, intermediate solution shows lower values for coverage and consistency.

The results show different combinations of variables that influence consumers' attitude towards AFVs. For instance, in the intermediate solutions, the configuration with highest coverage (0.137) and highest consistency (0.903) is the *car*clim*redn* (the symbol * indicates AND). These results mean that a combination of frequent use of car, attractiveness of AFVs in terms of climate change mitigation, and higher income is a sufficient condition for positive attitude towards AFVs (Bockarjova & Steg, 2014). These results are in line with Noppers et al., (2015) and Schuitema et al., (2013) who find that consumers have a more favorable attitude toward environmental innovations when explicitly confronted with instrumental, symbolic and environmental attributes.

In addition, the combination of *age*clim*redn* appears to be the unique core condition (Fiss, 2011) for a positive attitude towards AFVs; this condition is the only one appearing in both intermediate and parsimonious solutions.

The analysis of the negated outcome (i.e., definite non-interest in AFVs) shows some meaningful configurations (apart from the obvious total refusal configuration: *~car~exp~cost~redn~clim~know*). In particular, notice the relevance of the configuration

~age~cost~clim~know, which means that refusal of interest in AFVs depends on substantial indifference to environmental issues, irrespective of age and cost concern.

The results show that causal asymmetry occurs, meaning that some outcome configurations that lead to *–att* are not the negation of the same conditions leading to *att*, contrary to the case in Gonçalves et al. (2016).

This study's findings support, among others, Egbue & Long (2012), who, although use a non-representative sample, find out that a moderate to high interest in AFVs exists. Their study shows that cost and performance, and the concept of sustainability have a major influence on AFVs adoption.

5. Discussion and conclusions

This study analyzes youngsters' attitude toward AFVs using fsQCA. The results show that both intermediate and parsimonious solutions have consistency values of 0.75 and 0.70 respectively, and coverage values of 0.89 and 0.93, respectively. Therefore, the conditions have a high degree of representativeness in the model that the study proposes.

These findings confirm that concerns about the environment do influence purchase intention of AFVs (Carley et al., 2013). These findings support Gallagher and Muehlegger (2011), who suggest that levels of education, income, and environmentalism positively correlate to likelihood of AFVs purchase.

These results of this study also offer relevant practical implications for both policymakers and manufacturers.

First, public campaigns promoting AFVs can contribute in the long run to attain a long-lasting effect for a better sustainable environment. Younger generations, especially those who use private cares to move around, are more attentive to environmental friendly

measures like AFVs. Therefore, appropriate government campaigns to raise environmental consciousness can indirectly affect decisions to favor new means of sustainable transport.

Second, the determinants of the negative attitude suggest where to focus additional public information and private business advertising. Absence of some direct experience and ignorance of climate issues appear to be among the main drivers of such negative attitude toward AFVs. Consequently, public policies for education toward environmental sustainability can dissipate this negative attitude and, in the long run, can help to build a better consciousness in the new generation of adult consumers. At the same time, the business sector can adopt new ways to promote the direct experience of AFVs among youngsters. In addition, public policy actions should support the implementation of adequate charging station infrastructure to facilitate the transition to AFVs. Car industries should take into account consumer preference for shaping future technological developments.

Finally, communication, education, and policies can involve consumers in environmental policies and consequently influence their purchase decision towards AFVs. Understanding what concerns and attracts the younger generations regarding AFVs can help marketing manufacturers and policy makers in designing strategies to overcome some barriers to adoption of AFVs.

Little research exists that analyzes factors influencing AFVs adoption. Thus, this study fills this gap in the literature by analyzing youngsters' perception of AFVs to investigate their purchase intention such vehicles. These results can support and lead to a better understanding of the major barriers and challenges that AFVs face.

The limitation of this research lies in a small sample of the population of youngsters which is not fully representative of the whole country. However, the study provides insights about preferences and attitudes of high-educated youngsters.

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Table 1. Questionnaire scores of relevant questions to transportation (% of respondents)

	1	2	3	4	5	Average score*
Usual transportation mode						
Private car	9.38	6.85	9.13	18.52	56.12	4.1
Bus	27.64	23.36	17.09	14.25	17.66	2.7
Train	42.45	21.37	15.10	11.97	9.12	2.2
Motorcycle	55.56	14.53	19.95	5.12	4.84	1.9
Bike	47.86	35.05	10.54	3.98	2.56	1.8
Walk	6.84	25.07	28.49	23.93	15.67	3.2

Have you have ever tried AFVs?	Yes	Not
BEVs	4.50	95.50
HEVs	11.67	88.33
PHEVs	0.30	99.70

	1	2	3	4	5	Average score*
Attractiveness of AFVs' related Benefits						
Reducing oil consumption	4.55	9.12	19.94	30.48	35.91	3.8
Climate change mitigation	3.13	5.41	15.10	36.47	39.89	4.0
Cost significantly less to fuel	2.27	5.41	7.41	22.22	62.69	4.4
Low level of noise	5.41	14.81	19.94	27.64	32.19	3.7
Less maintenance	12.25	16.24	29.34	24.50	17.66	3.2

Concerns about AFVs	
Driving range	33.00
Charging station infrastructure	25.00
Purchasing costs of AFVs and cost of batteries	18.00
Reliability	12.00
Safety	7.00
Charging time	2.00
Less performance	1.00

* average value from data of the 1-5 Likert scale

Table 2. Truth table for the outcome positive attitude towards AFVs (variable“att”) and six independent variables: clim, know, redn, exp, car, age.

clim	know	redn	exp	car	age	Number	raw consistency
1	1	0	0	1	0	32	0.8094
1	0	1	0	1	0	21	0.7835
1	0	0	0	1	0	21	0.8045
1	1	1	0	1	0	20	0.8231
1	1	0	0	0	0	12	0.8800
1	1	1	1	1	0	11	0.8148
1	1	1	0	0	0	5	0.9108
1	0	0	0	0	0	5	0.9107
1	1	0	1	1	0	4	0.8772
1	0	1	1	1	0	4	0.8638
1	0	0	1	1	0	4	0.8533
0	1	1	0	1	0	3	0.9268
1	1	1	1	0	0	2	0.8632
1	0	1	0	0	0	2	0.9347
0	0	1	1	1	0	2	0.8545
0	0	1	0	1	0	2	0.8892
0	0	0	0	0	0	2	0.8865
1	1	1	1	1	1	1	0.9717
1	1	1	0	1	1	1	0.9546
1	1	0	1	1	1	1	1.0000
1	0	1	1	0	0	1	0.8212
1	0	1	0	1	1	1	0.9350

clim	know	redn	exp	car	age	Number	raw consistency
1	0	1	0	0	1	1	0.9336
1	0	0	1	0	0	1	0.8857
1	0	0	0	1	1	1	0.9171
0	1	0	0	1	1	1	0.9631
0	1	0	0	1	0	1	0.8798
0	0	1	0	0	0	1	0.9449
0	0	0	0	1	0	1	0.8560
0	0	0	0	0	1	1	0.9410

Table 3. Results of intermediate solutions for positive attitude towards AFVs (att) and negative attitude towards AFVs (-att).

Intermediate solutions (att)

Casual configuration	row cov.	uni. cov.	cons.
car*clim*redn	0,137	0,000	0,903
age*clim*redn	0,106	0,000	0,898
age*car*clim	0,115	0,001	0,888
car*know	0,124	0,006	0,885

Solution coverage: 0.89

Solution consistency: 0.75

Intermediate solutions (-att)

Casual configuration	row cov.	uni. cov.	cons.
~car~know	0,261	0,009	0,867
~car~exp	0,267	0,030	0,729
~car~exp~cost ~redn~clim~know	0,110	0,005	0,969
~age~exp~redn~clim	0,174	0,021	0,948
~age~redn~clim~know	0,157	0,012	0,958
~exp~know	0,133	0,006	0,901

Solution coverage: 0.80

Solution consistency: 0.75

Parsimonious solutions (att)

Casual configuration	row. cov.	uni. cov.	cons.
age*clim*redn	0,106	0,000	0,898
age*car*clim*redn	0,115	0,000	0,926
age	0,201	0,005	0,845
Know	0,716	0,087	0,725

Parsimonious solutions (-att)

Casual configuration	row cov.	uni. cov.	cons.
~clim	0,393	0,106	0,834
~redn	0,267	0,028	0,779
~car	0,396	0,121	0,716
~exp	0,163	0,025	0,798

Exp	0,243	0,033	0,557

Solution coverage: 0.93 Solution consistency: 0.81

Solution consistency: 0.70 Solution coverage: 0.69